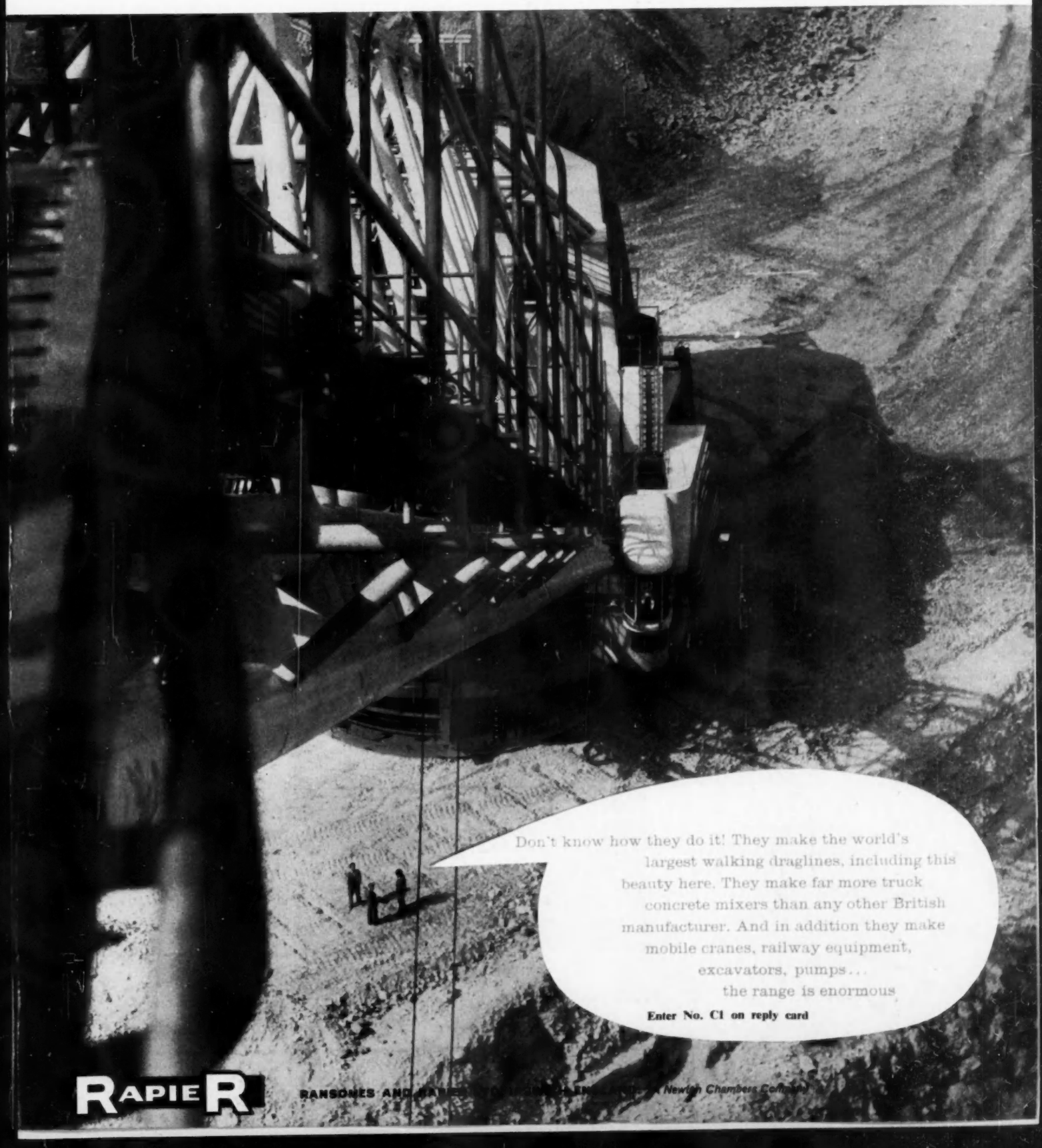
THE ENGINEER

SEPTEMBER 2, 1960 | 28 ESSEX STREET, STRAND, LONDON, W.C.2 | TWO SHILLINGS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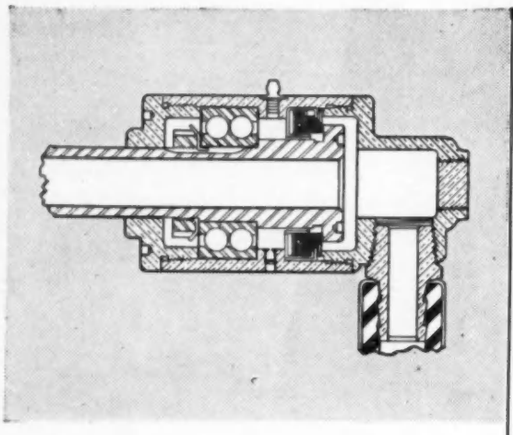
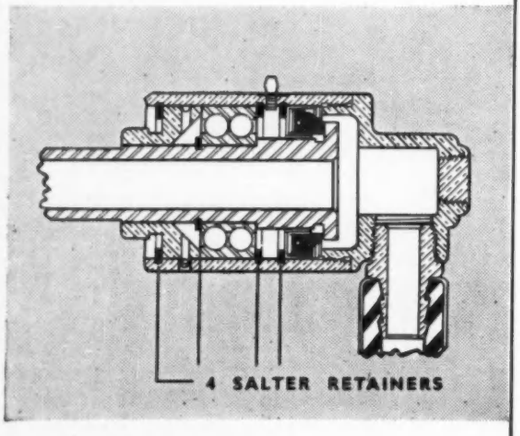
Salter retainers simplify design of air, water, steam union, with great savings



THE OLD WAY Air, water, steam union involved drilling, threading and milling operations. Maintenance was difficult.



THE SALTER WAY Salter retainers permit rapid, simple assembly and maintenance with a reduction in manufacturing costs.

MATERIALS SAVED		
decreased wall thickness of housing	2/9¾	*
eliminated bearing lock nut and washer	7¾	
MACHINE OPERATIONS ELIMINATED		
bore, undercut, and tap cap end of housing	1/4¾	
locate cap on arbor, and chase threads	1/-	
drill spanner wrench holes	4¼	
cut thread on rotor for lock nut	3¾	
mill slot in thread for tang on lock washer	7½	
drill spanner wrench holes in rotor	4¼	
ASSEMBLY OPERATIONS ELIMINATED		
install lock washer, tighten lock nut, bend lug	8½	
assemble cap into housing	4	
TOTAL SAVING WITH SALTER RETAINERS	8/6½	

4 SALTER RETAINERS simplify design, assembly and maintenance with a saving of 8/6½ per unit

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No. 5458 **SEPTEMBER 2, 1960** VOL. 210

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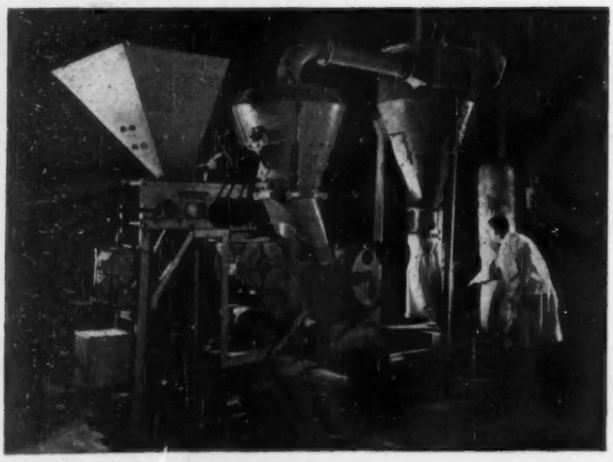

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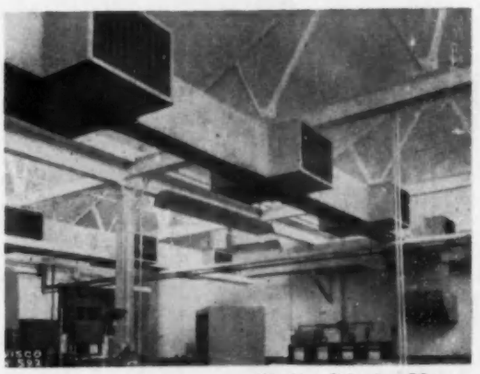

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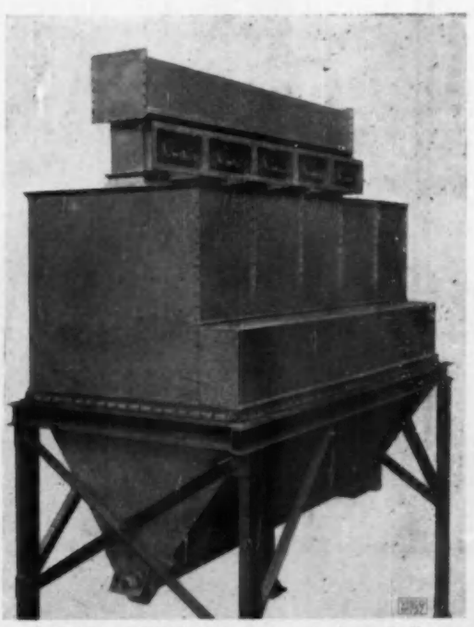

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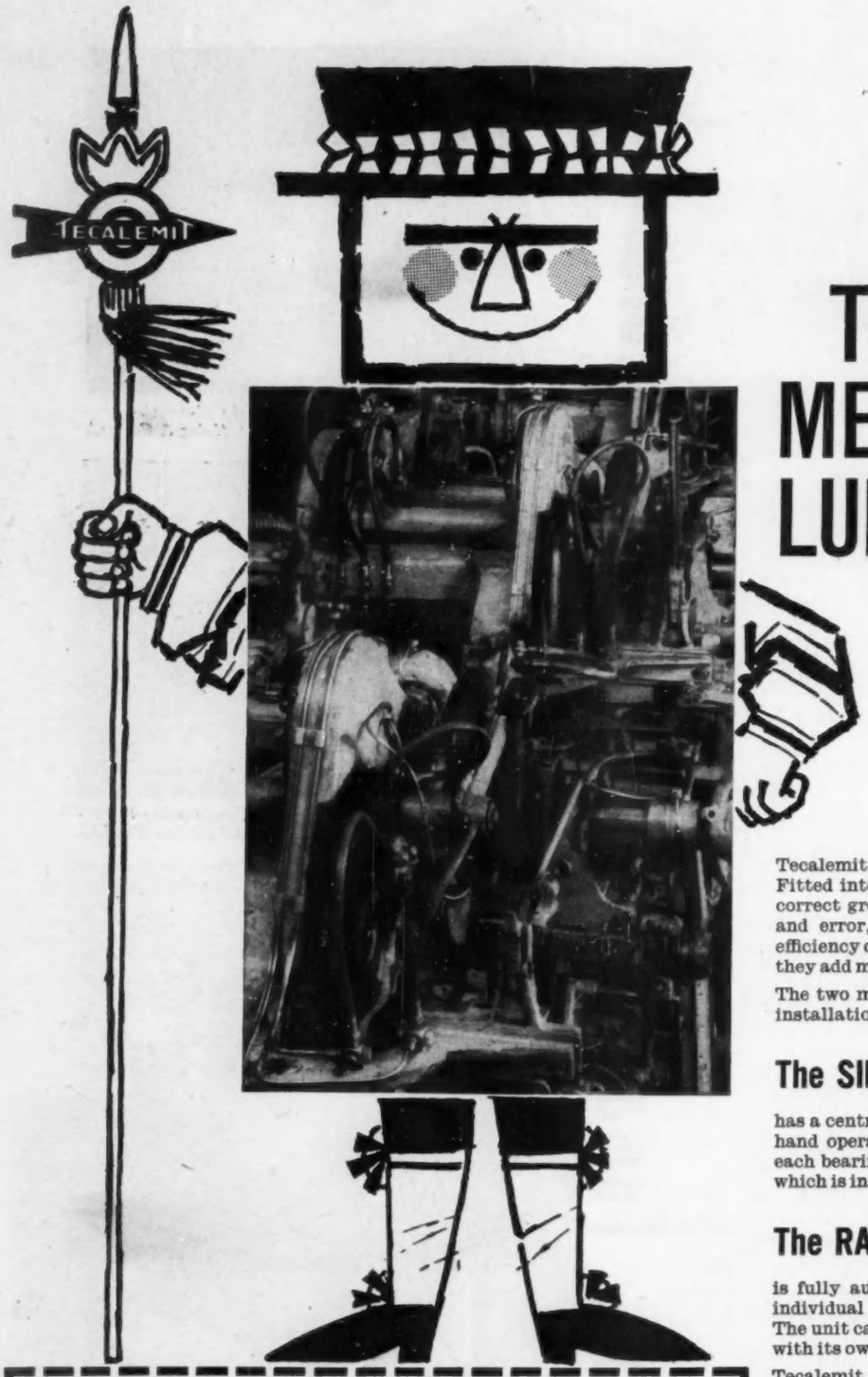

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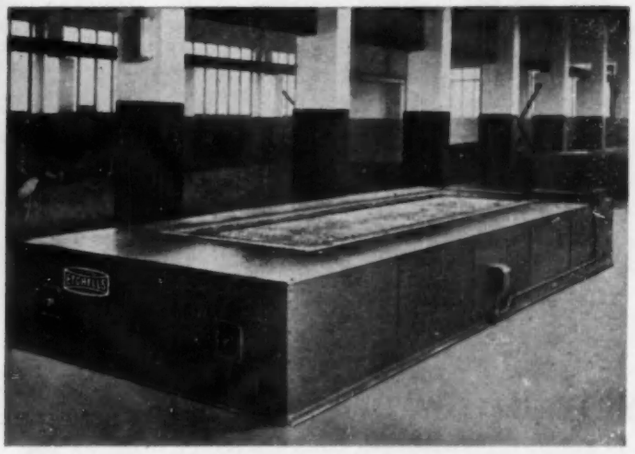

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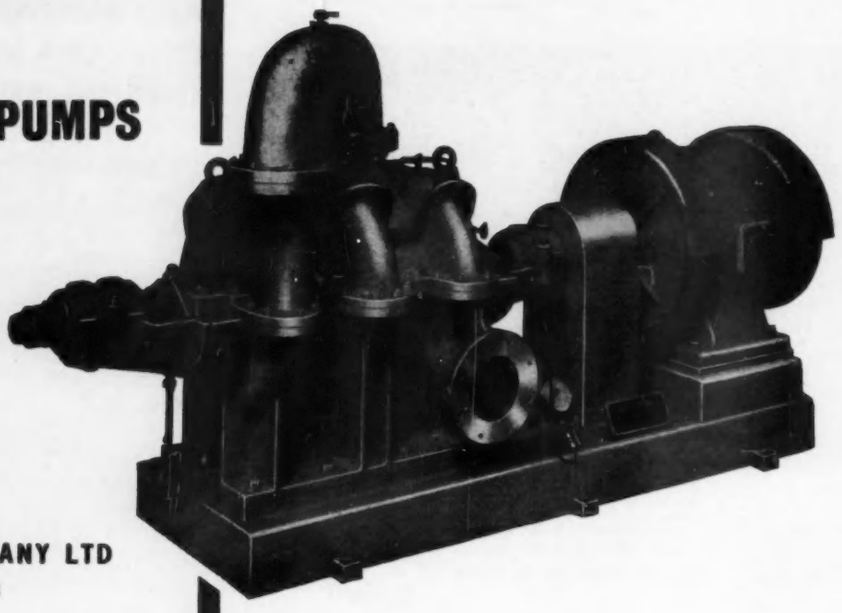

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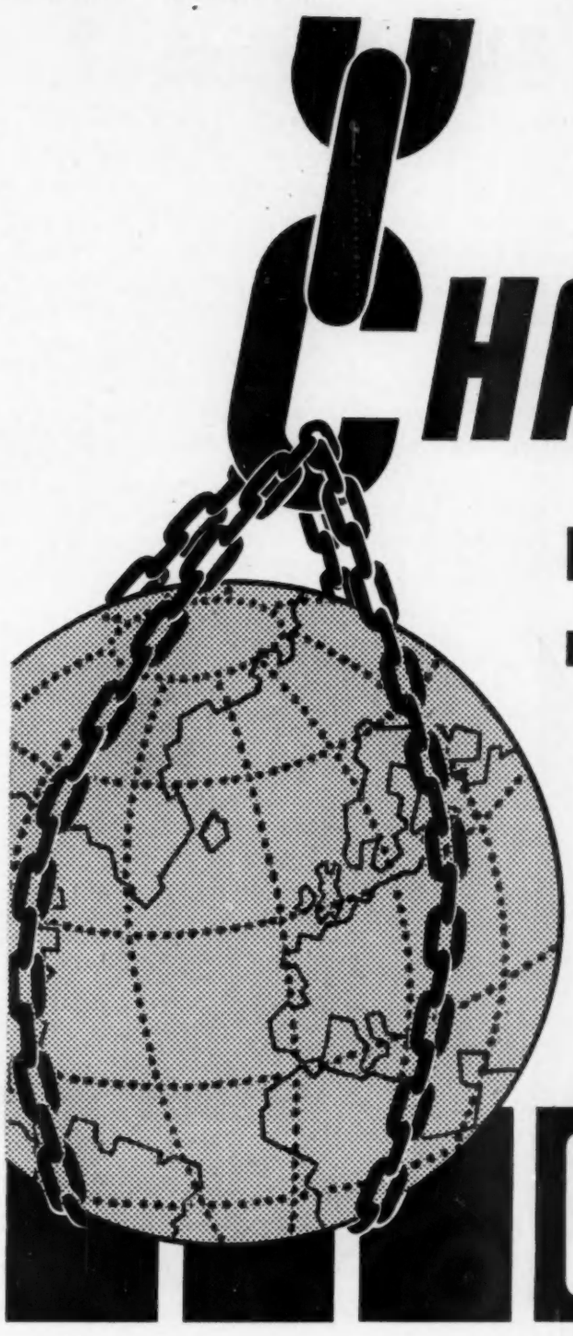

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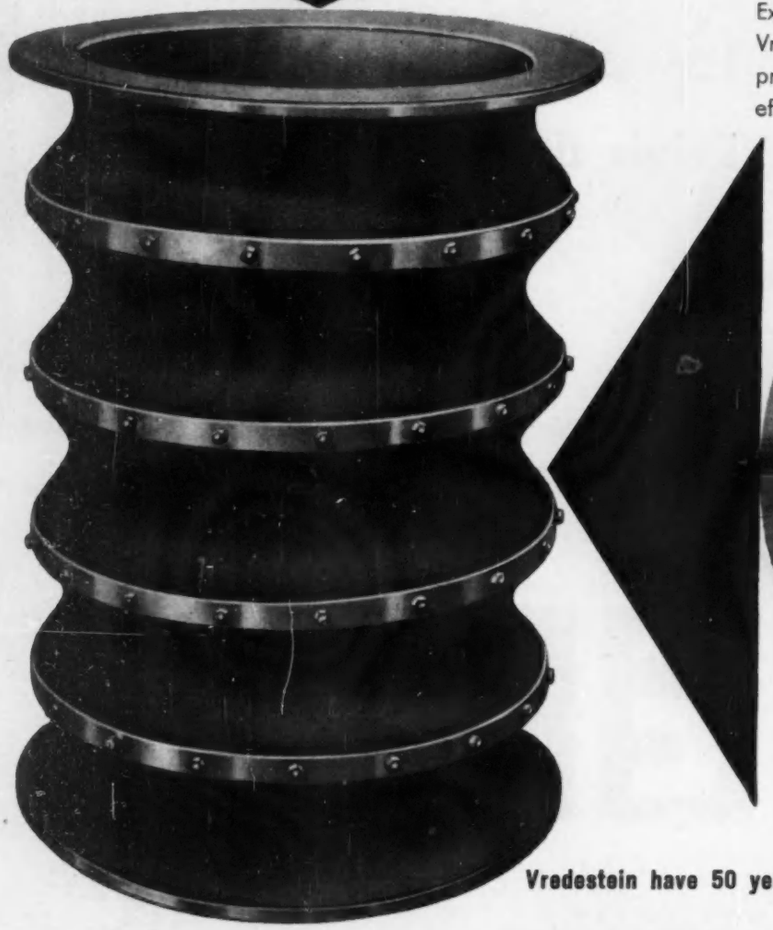

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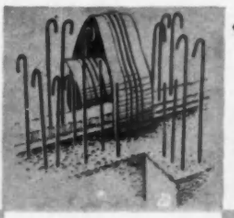

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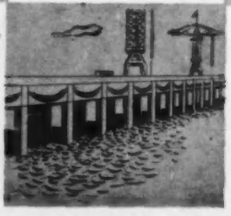

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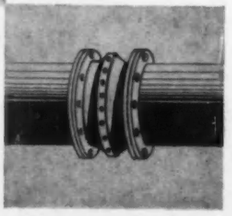

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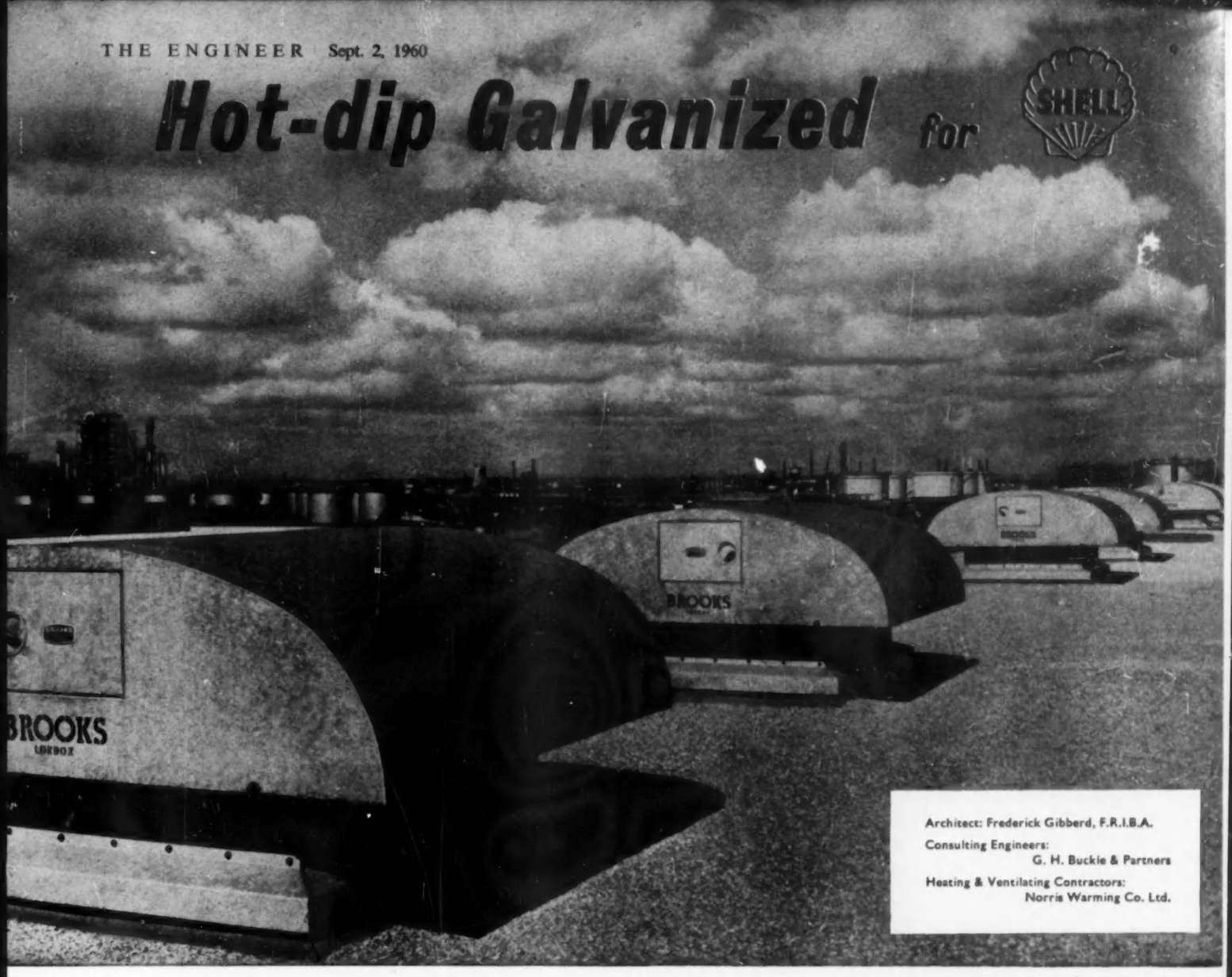

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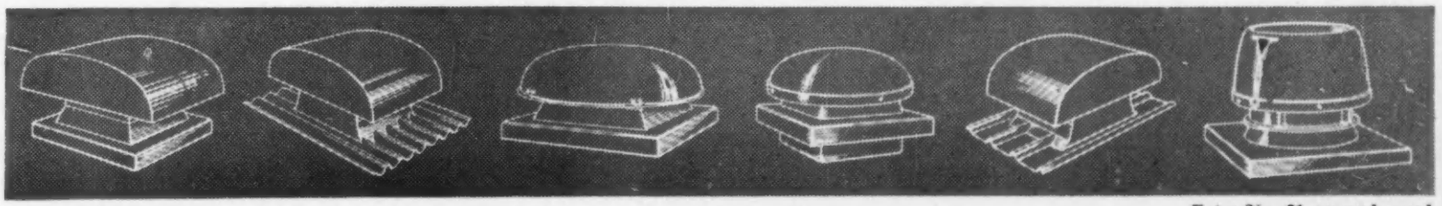

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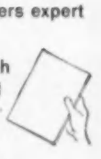

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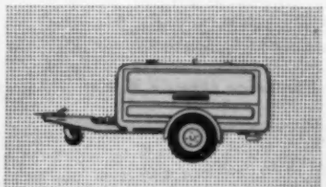
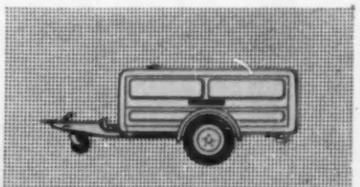


VT5 Weight 2,900 lb (1315 kg) 225 c.f.m. (6.4m³/m)



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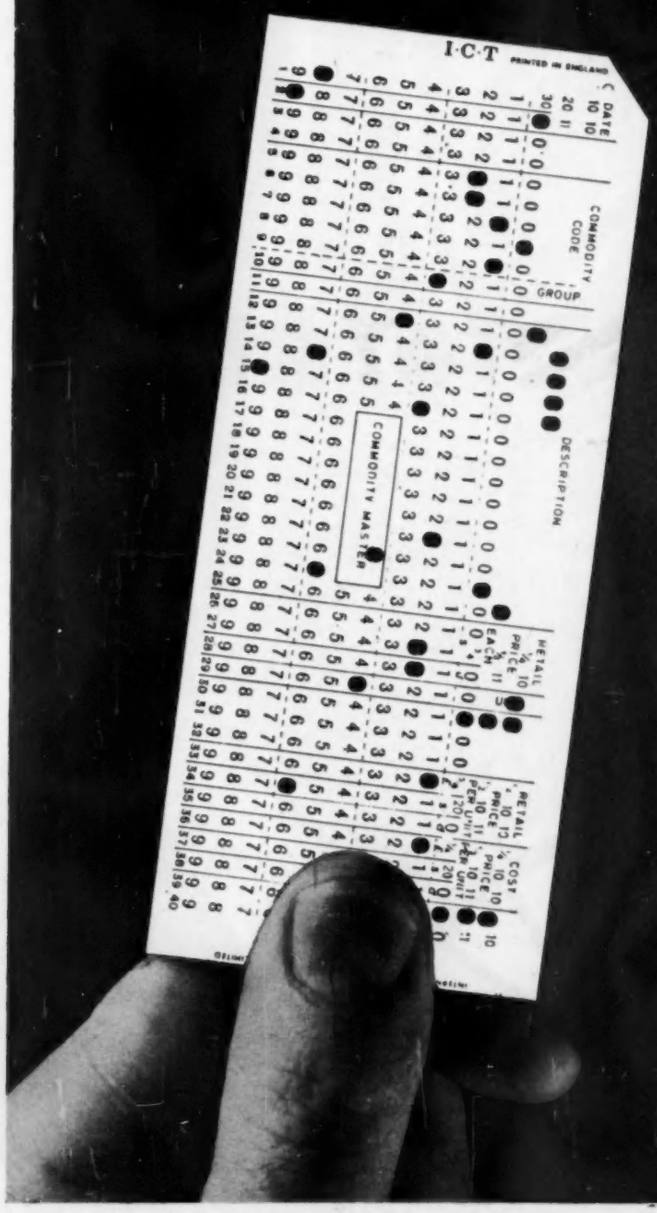
I·C·T 40-COLUMN PUNCHED CARD SYSTEMS can help your business



WHAT DOES 40-COLUMN MEAN? It means a punched card data processing system using small cards which record data in 40 columns—quite sufficient for a large number of jobs. It means a comprehensive range of 40-column punched card machines. Compared with a larger 80-column installation, it means less initial outlay, lower running costs, saving of floor space.

If you're considering a data processing system, see what 40-column machines will do for you. They are more than earning their keep for many thousands of organisations: firms operating with as few as 12 people to concerns employing over a thousand.

What I·C·T 40-column equipment can do for YOU

It will mechanise your sales and purchase accounting, and produce your statistical records. Other everyday jobs it will tackle include stores and stock control, invoicing, payroll, hire purchase accounting, expenditure control and costing. It will help you wherever you need accurate accounting and statistical information quickly.

The equipment is readily available; it is easy to put in and simple to use.

I·C·T 40-column equipment can grow with your firm

The basic machines—auto punches, sorters and tabulators—may be all you want at the moment. But you can always add summary, reproducing and electronic calculating punches, interpolators and interpreters. And you can increase card capacity by 25% without spending a penny more.

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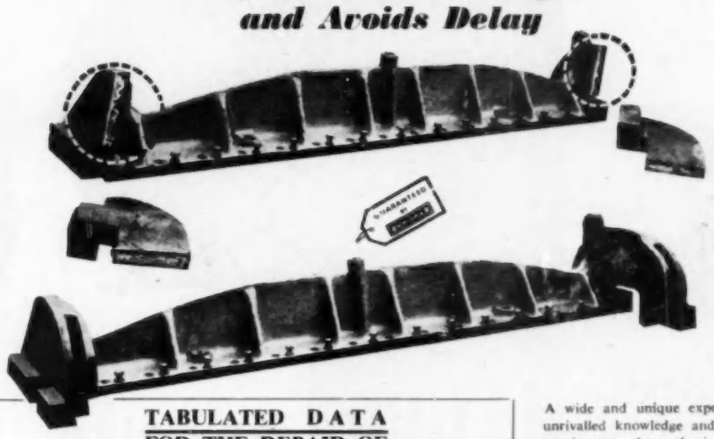
WHEN a Guillotine "Gives up the Ghost!"

BARIMAR Scientific Welding repairs the Breakage, and Avoids Delay



Sturdy they may be but guillotines and similar machines in industrial use are peculiarly prone to breakdown. Overloads, bad adjustment, blunt knives, unsuitable material — all these can result in serious fractures in "key" machines which delay production "all along the line".

Here is a guillotine knife holder, before and after a splendid Barimar welding repair job.

Pieces were broken off at both ends of this 12ft. casting, calling for not only sound, dependable welding, but also for absolutely accurate re-machining by Barimar.

Naturally the welding had to be perfect — the Barimar Money back Guarantee saw to that. Furthermore, the casting was returned to the owners and restored to service in double quick time, reducing production losses to an absolute minimum.

TABULATED DATA FOR THE REPAIR OF

GUILLOTINE side members	Shearing Machine Bodies
ditto knife holders	Punching Machine Bodies
ditto beams	Stamping Machine Bodies

PRESS BODIES OF EVERY KIND PRESS CRANK-SHAFTS PRESS CONNECTING RODS PRESS RAMS.

Scientific Welding repairs damaged parts
Every repair made under Barimar Money-back Guarantee

ALL BROKEN PARTS that are transportable must be sent CARRIAGE PAID or delivered to the nearest Barimar Branch address. Please remove all fittings, and post letter advising dispatch. When it is impossible to transport the damaged machinery, Barimar experts will operate ON THE SPOT.

A wide and unique experience, *extending over half a century*, enables Barimar experts to apply their unrivalled knowledge and skill to every emergency repair to guillotines and similar machines. Barimar repairs are pleasantly inexpensive, prompt, dependable and are covered by the Barimar Money-back Guarantee.

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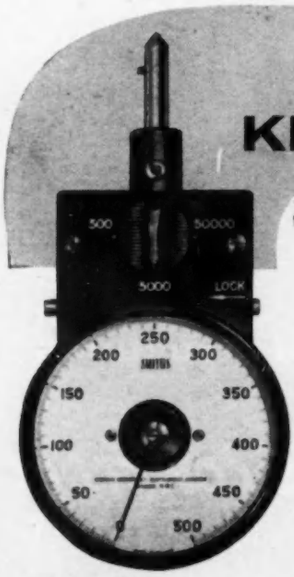

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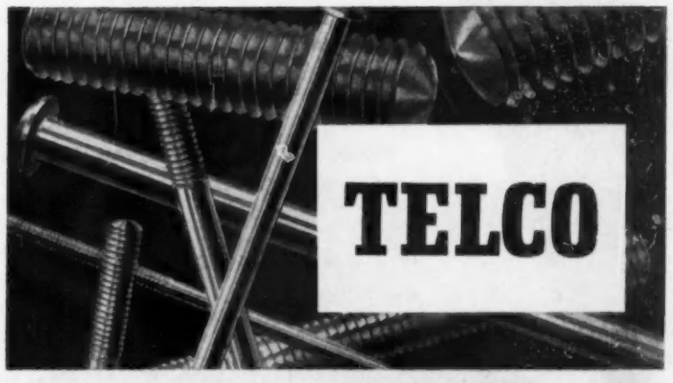

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TANKS any size

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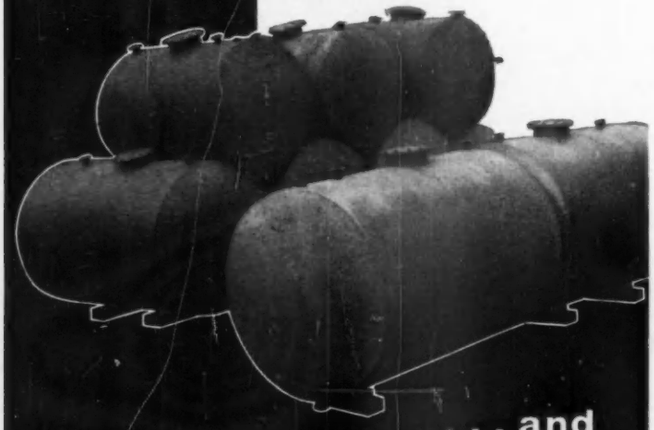

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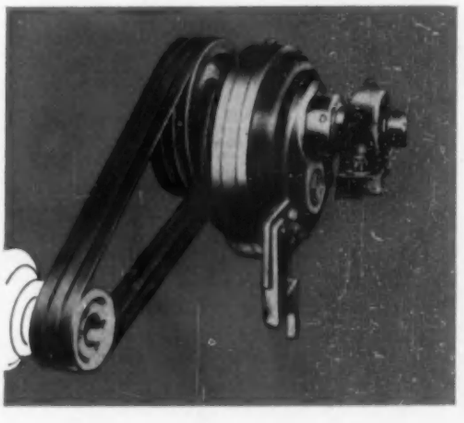

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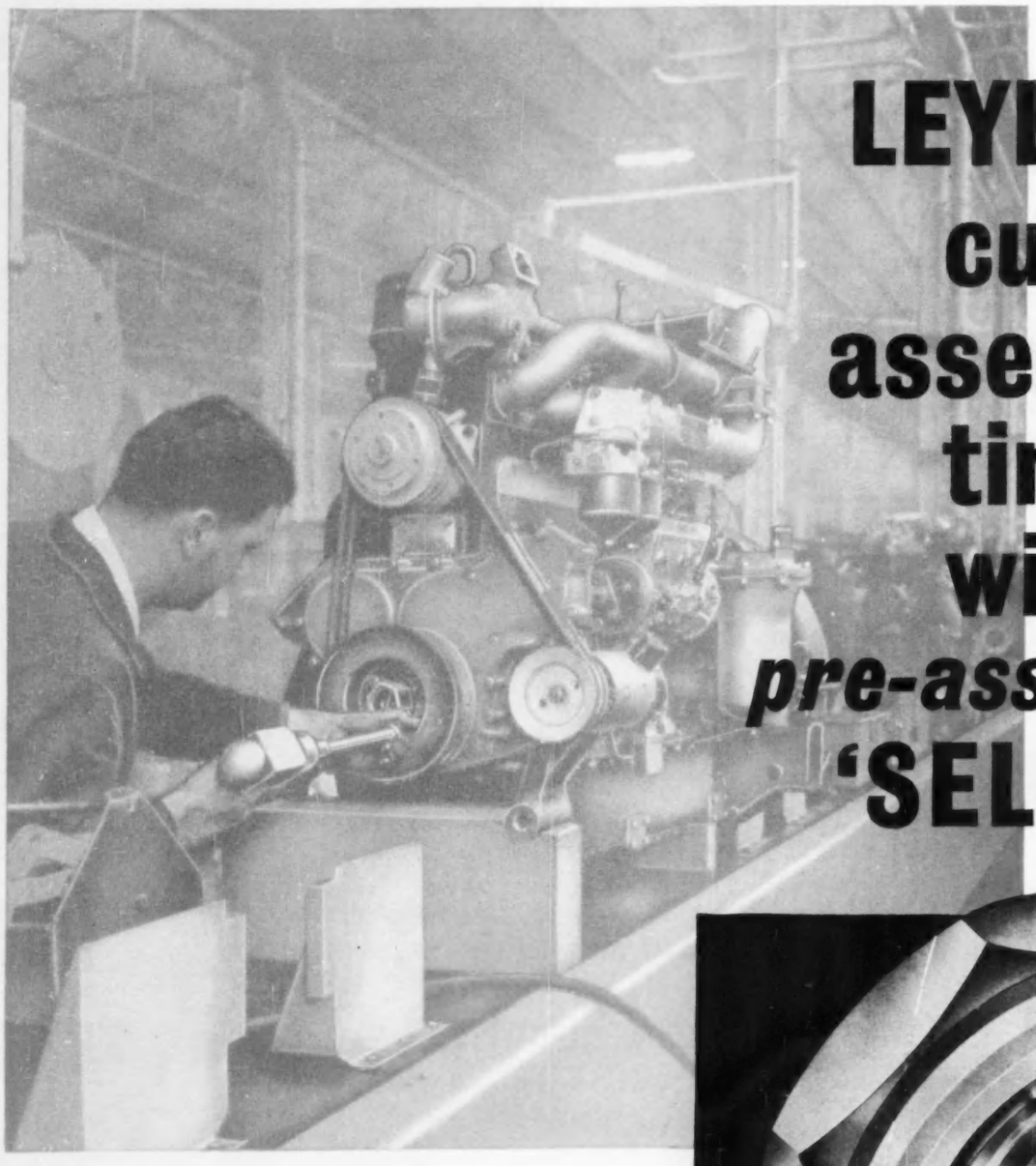

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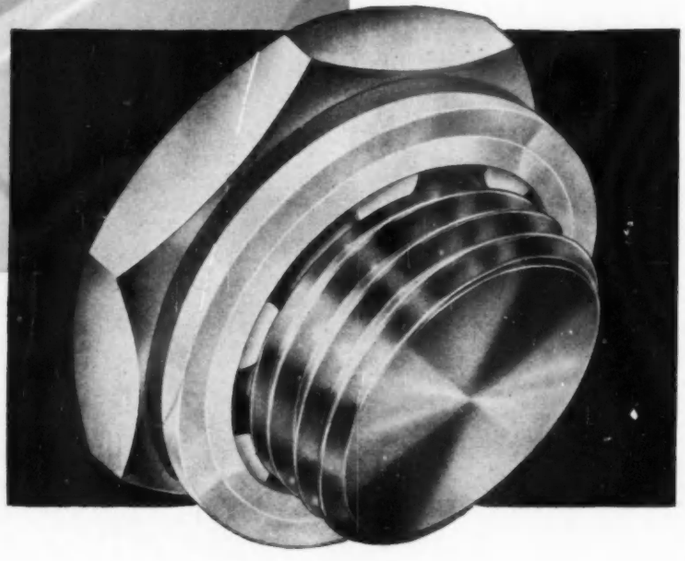

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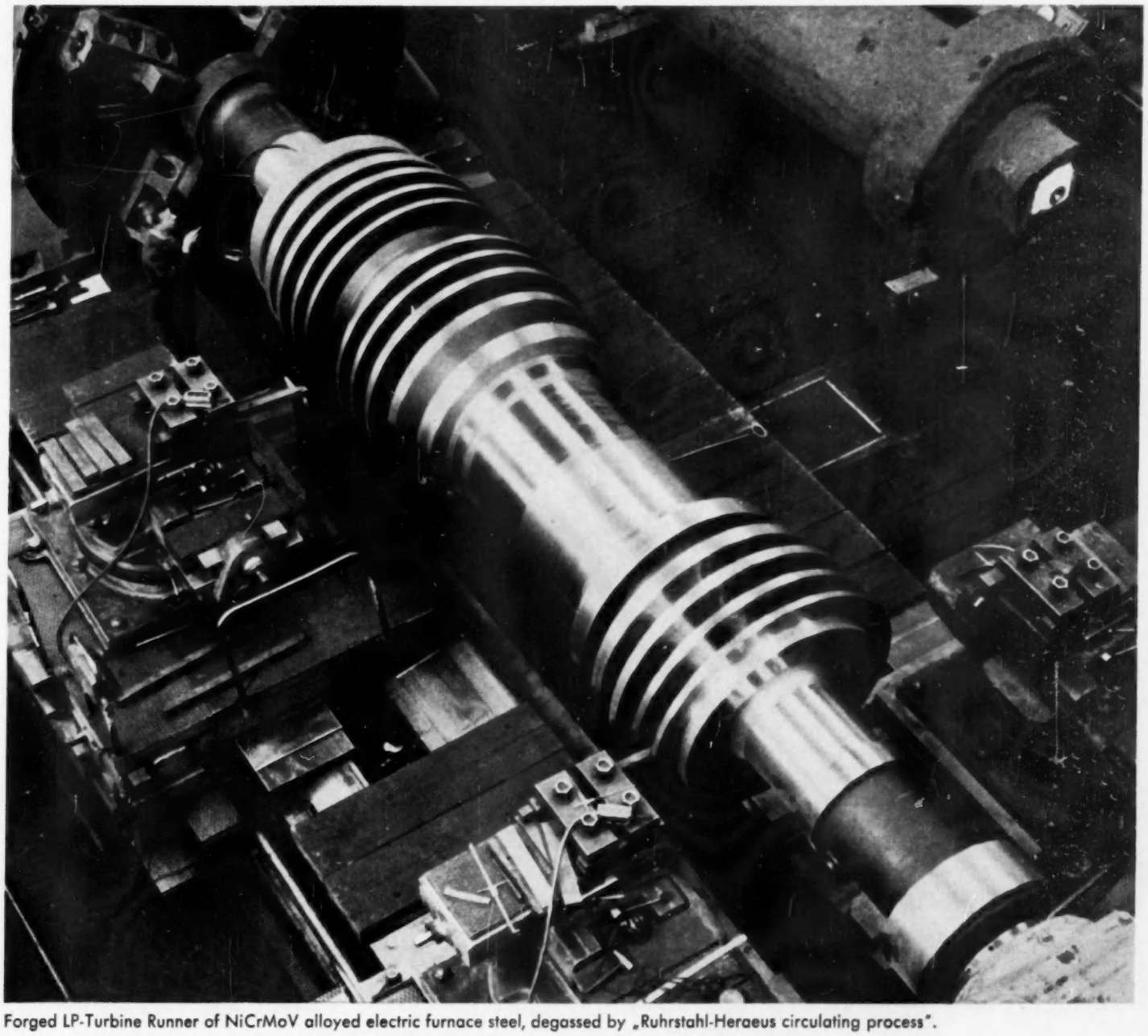

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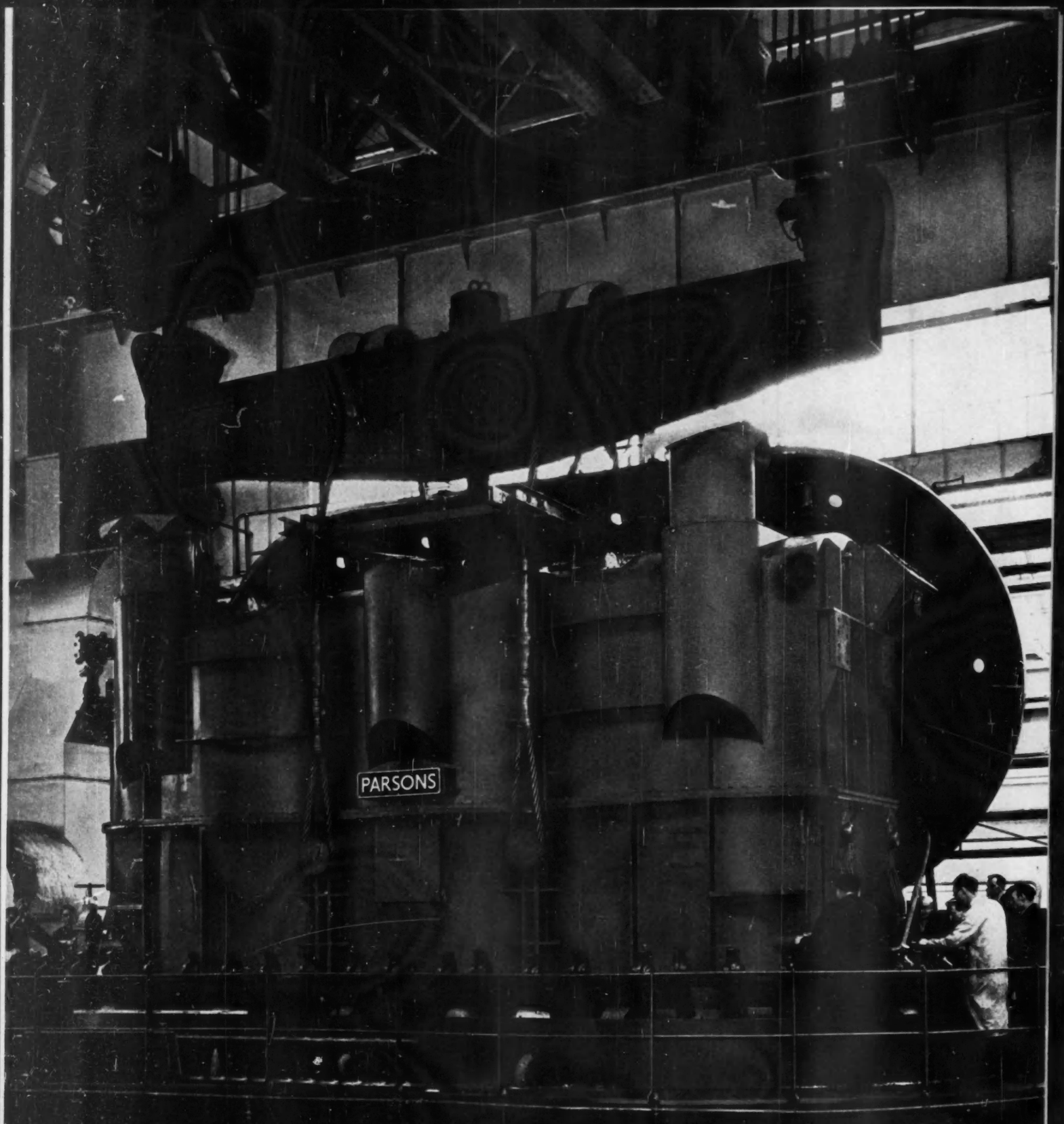

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Facilities are available to produce the largest EHV transformers yet envisaged.

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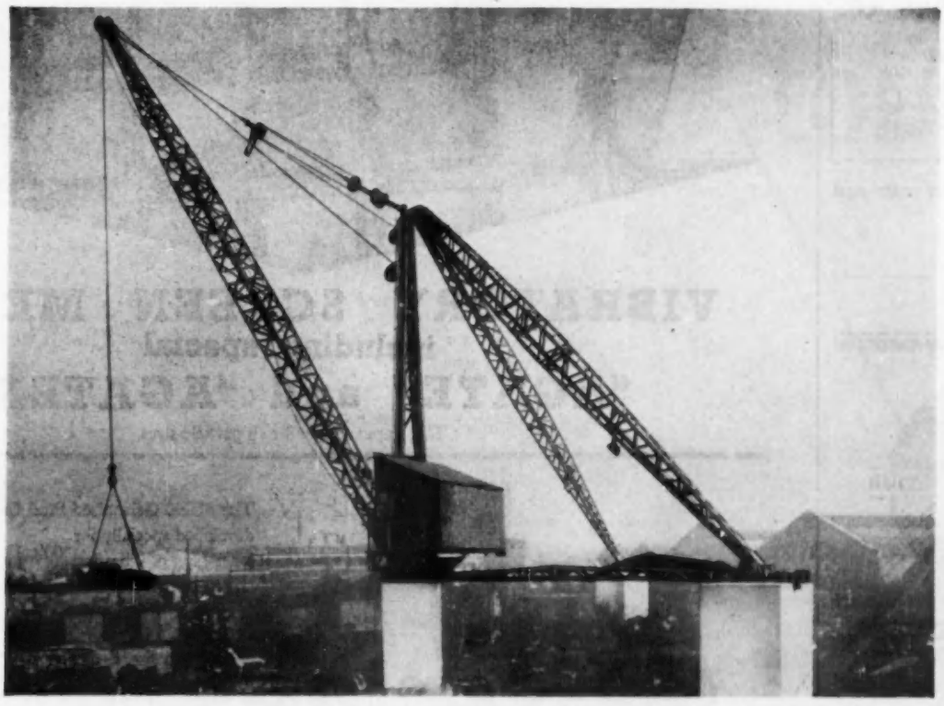

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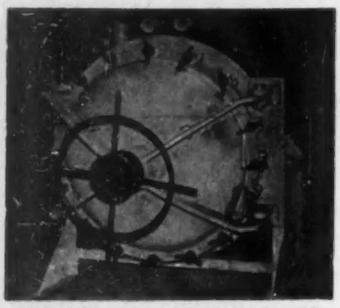

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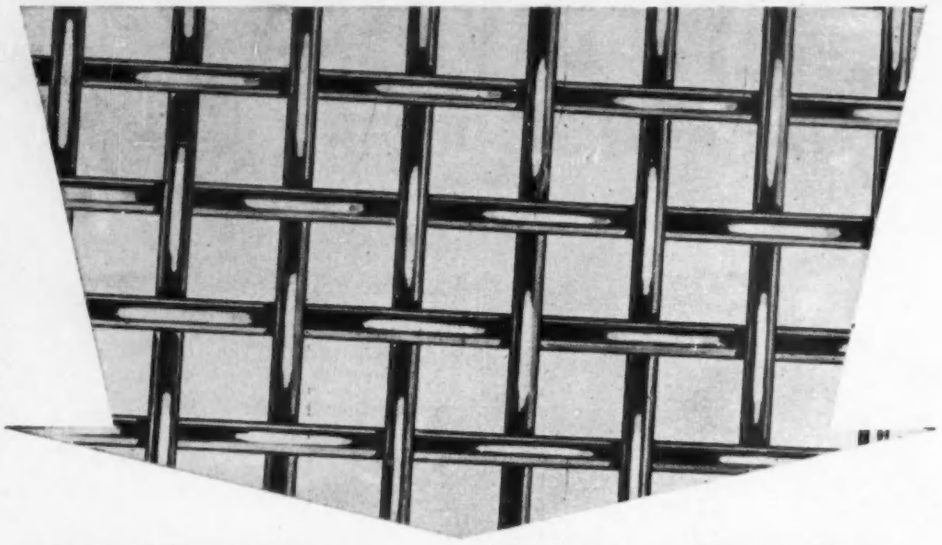

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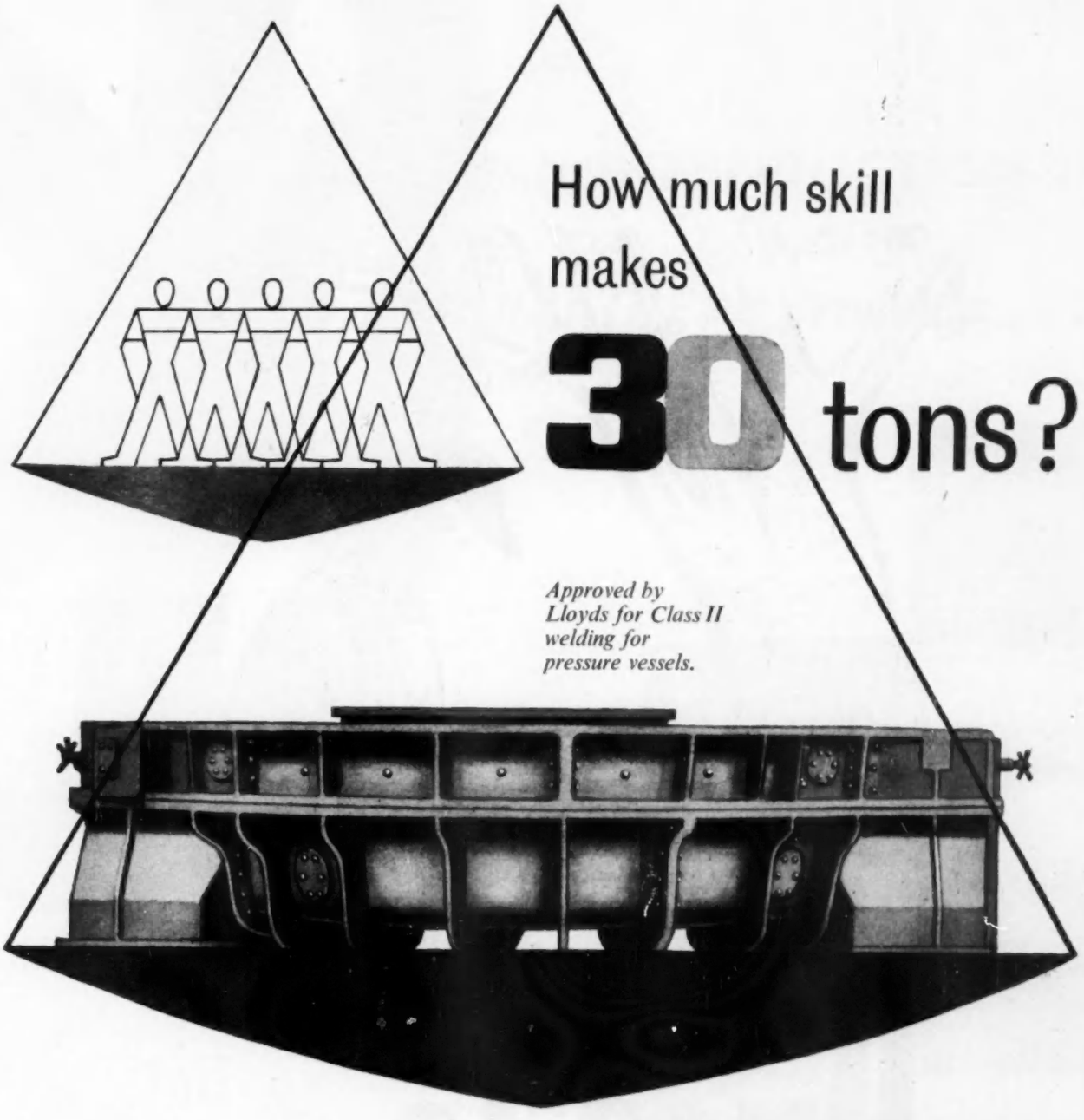

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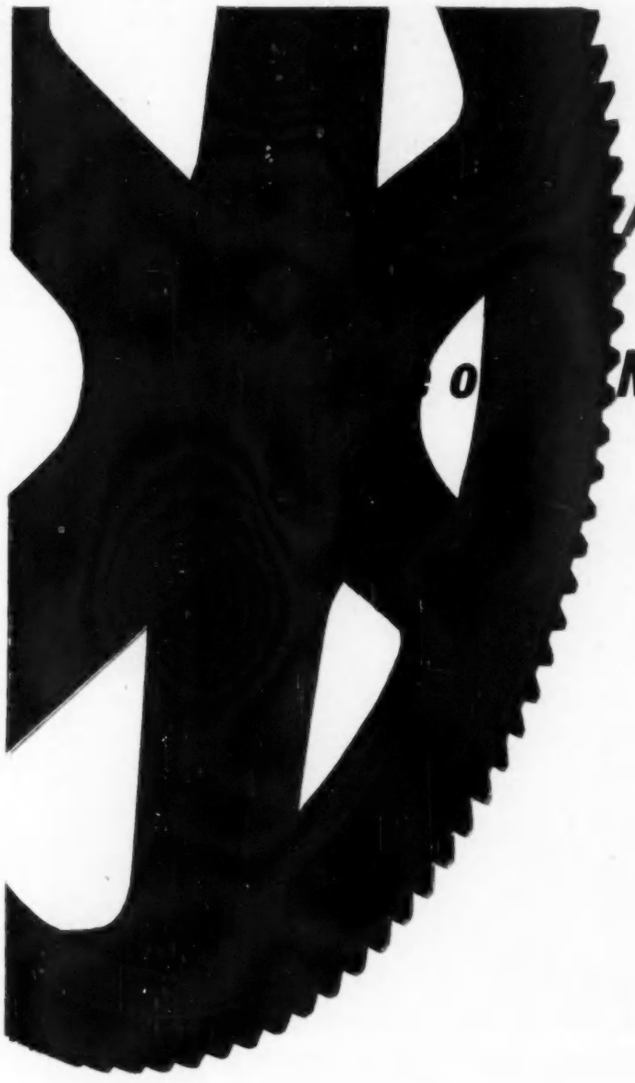

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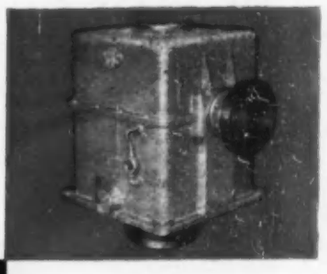

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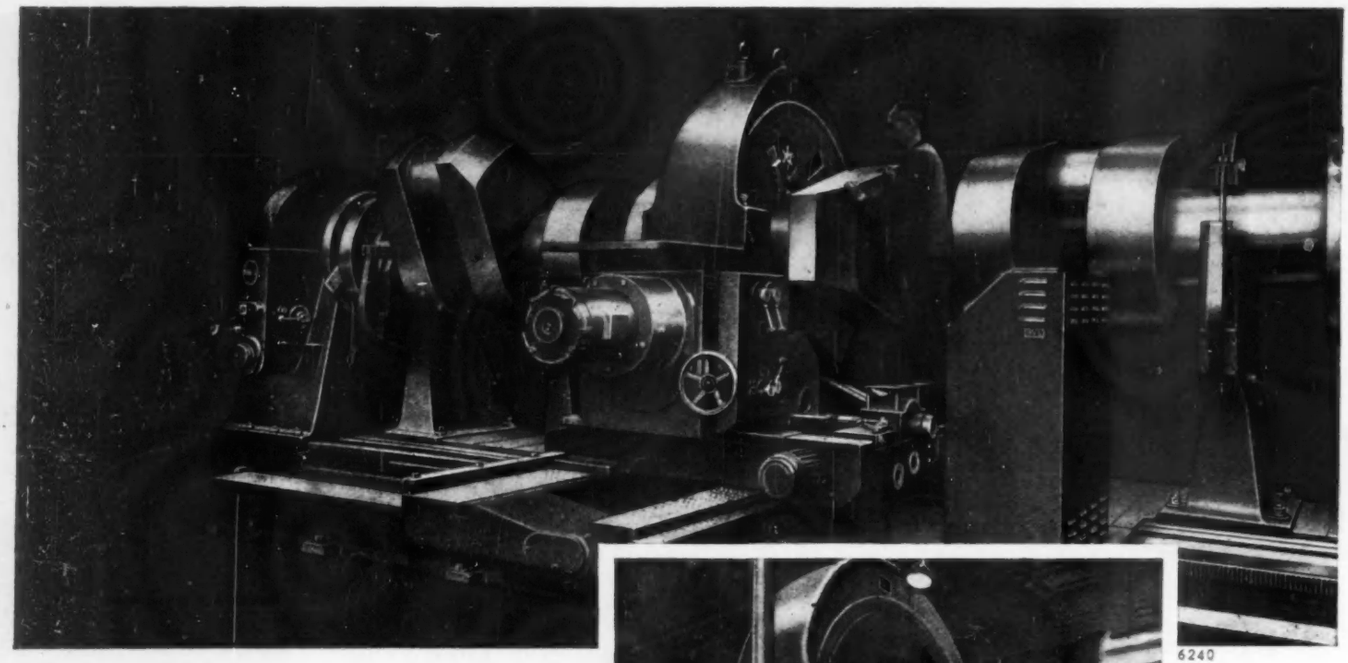
up to 900 mm diameter



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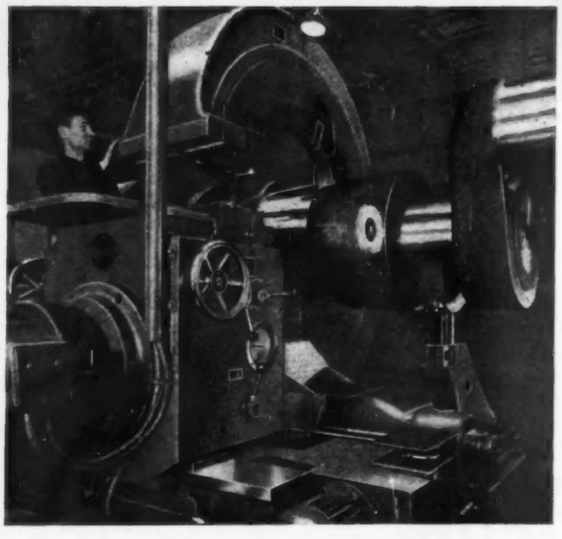

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Due to

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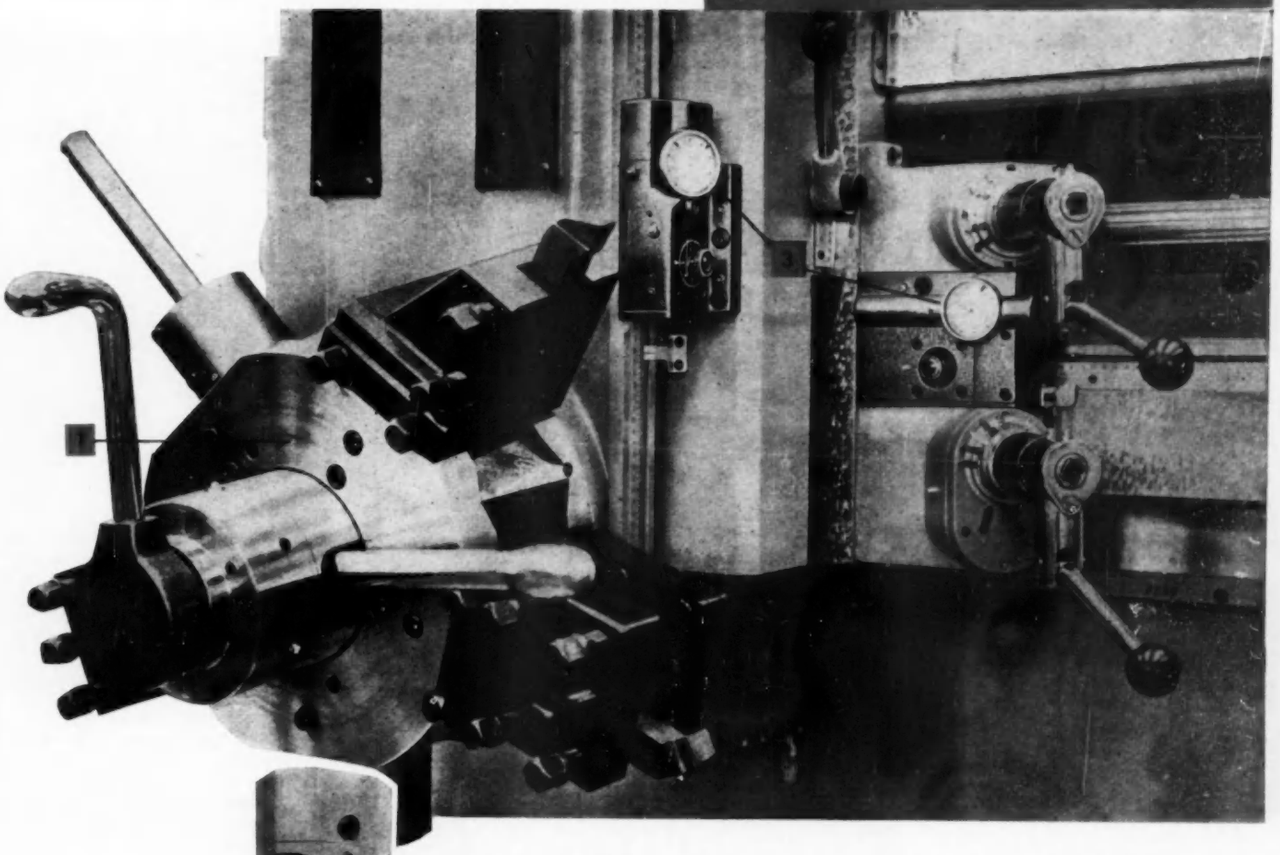

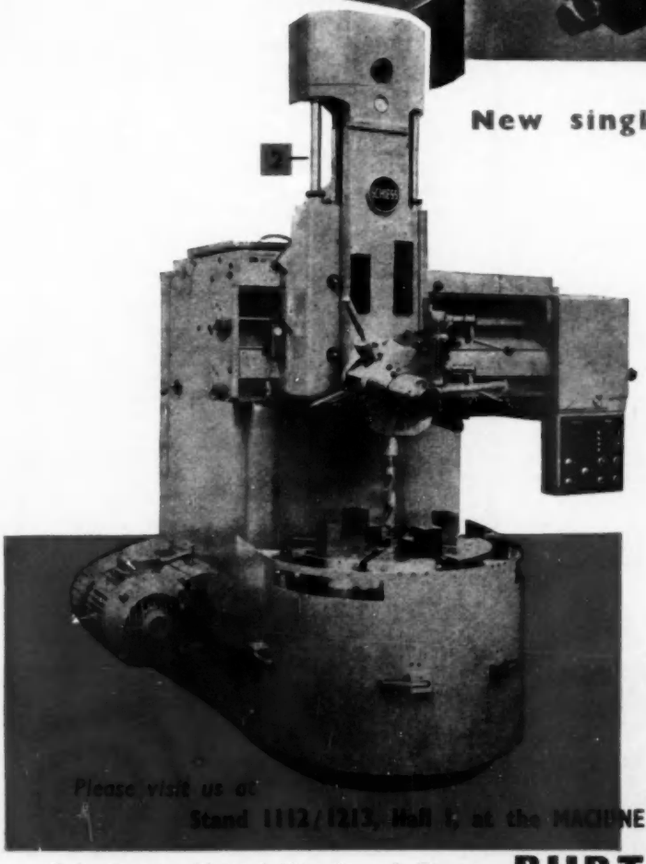

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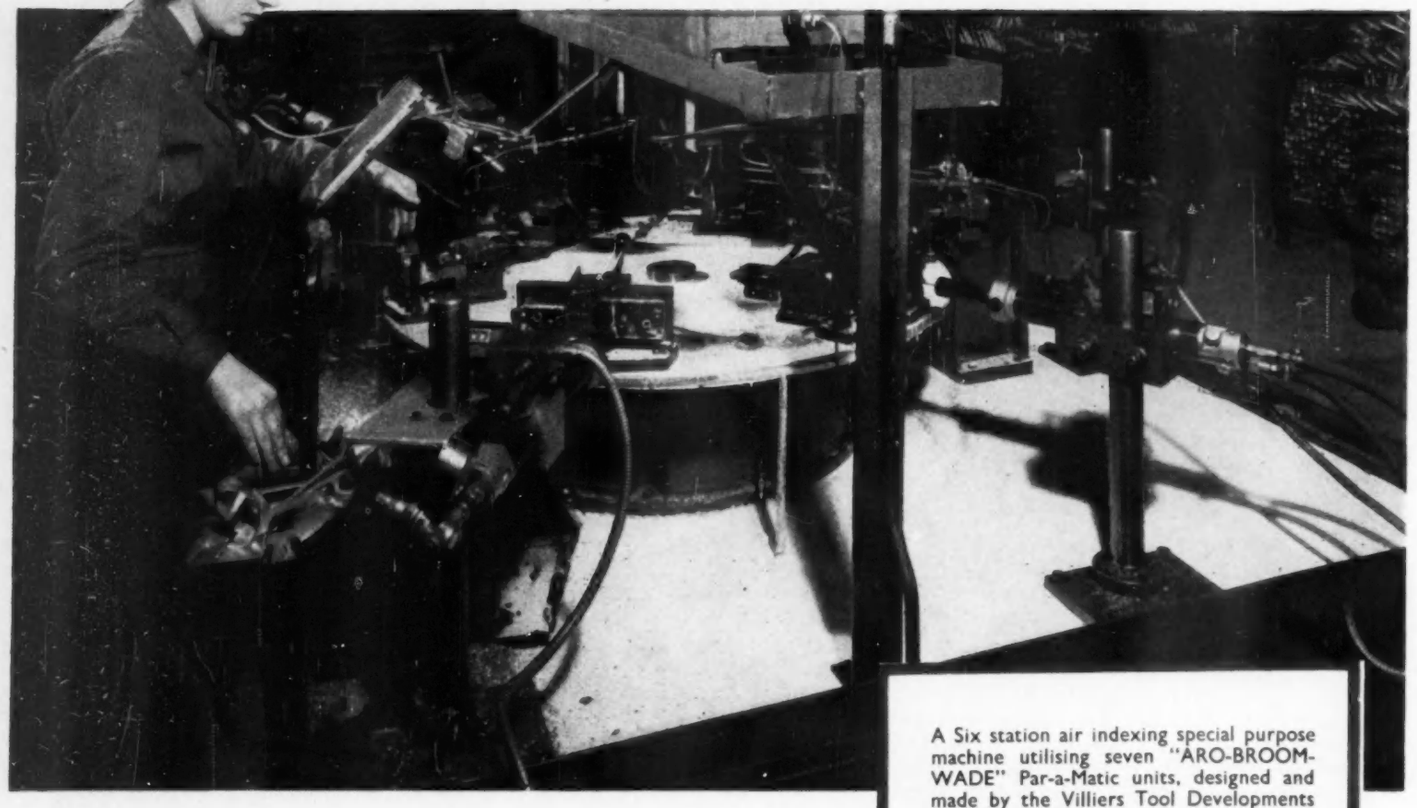
. . . with "ARO-BROOMWADE" Par-a-Matics



From 200 per *day* to 150 per *hour* — this is the remarkable increase that "ARO-BROOMWADE" Par-a-Matics have effected in the production of automobile door handles for Messrs. Fry's Diecastings Ltd.

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This machine carries out the following sequence of operations at a **production rate of 150 per hour. Previous methods produced only 200 per day.**

1st Station	... ...	Drill 2 holes for u.n.f. tapping
2nd Station	... ...	Tap 2 holes 10 u.n.f.
3rd Station	... ...	Drill 2 holes for 6 BA Tapping (Multi-head)
4th Station	... ...	Tap 1 hole 6 BA
5th Station	... ...	Tap 1 hole 6 BA
6th Station	... ...	Unload fixture & load fresh component

Special note should be made of the 2 spindle drilling head attached to the PAR-A-MATIC for drilling the 2 close spaced holes at Station No. 3.

Photograph by courtesy of Messrs. Fry's Diecastings Ltd.

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Clamping for Safety

with the ODONI MACHINE BED CLAMP

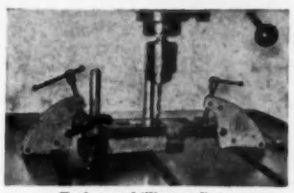
An entirely new design in Machine Bed Clamps, now in use in workshops throughout the country, is making the machining of small parts easier and safer.

The Odoni Machine Bed Clamp has these features:

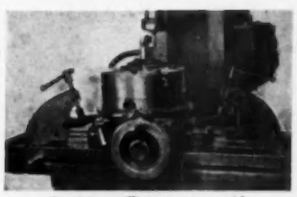
Clamps any thickness from .001 in. to 2¼ in
Fully open to fully closed in a few turns
No spanner, packings, shims or other makeshift required.
Swivels in any direction without adjustment.
Over ½ ton pressure can be applied.

Supplied with bolts and heavy washers for T-slots. Base fitting tapped ⅜ in. Whitworth. Finished in grey hammer stove. Obtainable through Engineer's Merchants or direct from the manufacturers, price £2.17.6 per pair.

Drilling 1½" diam. through 1½" mild steel



Tool room drilling on die set



Precision milling on rotary table

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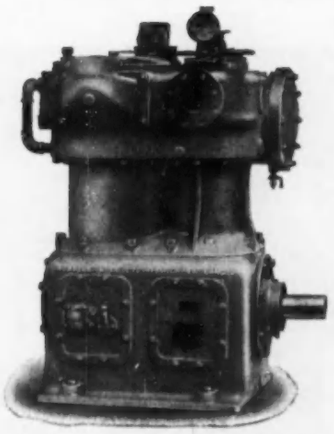
TWO STAGE.	100 LB. PER SQ. IN.	200 TO 310 CU. FT. PER MIN.



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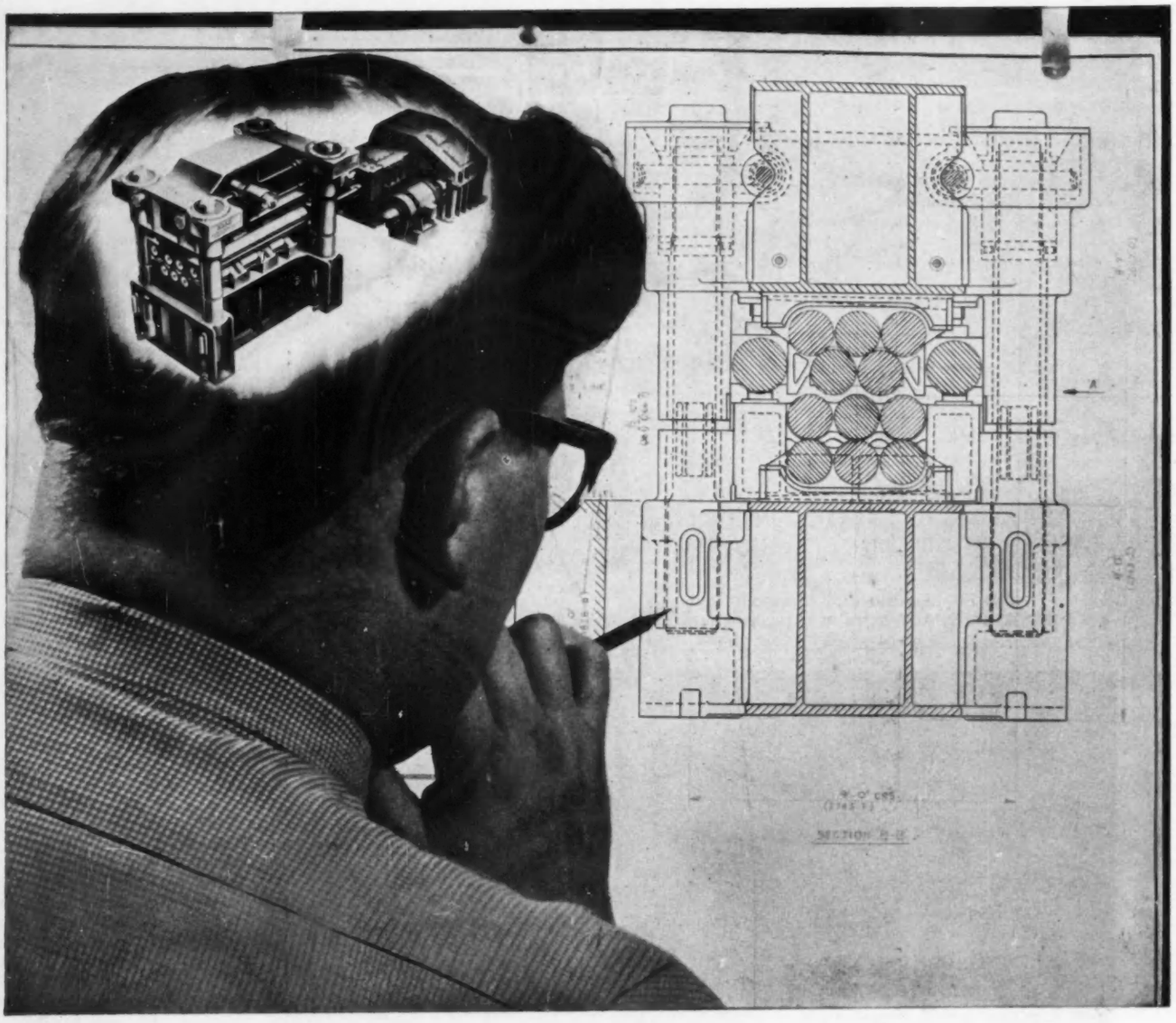
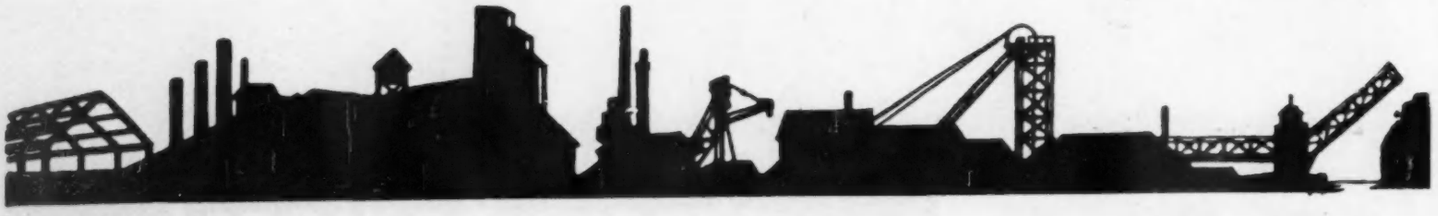
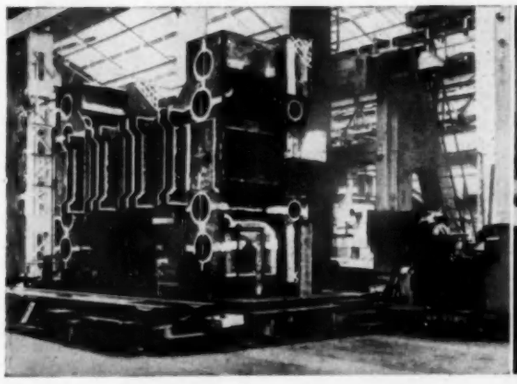


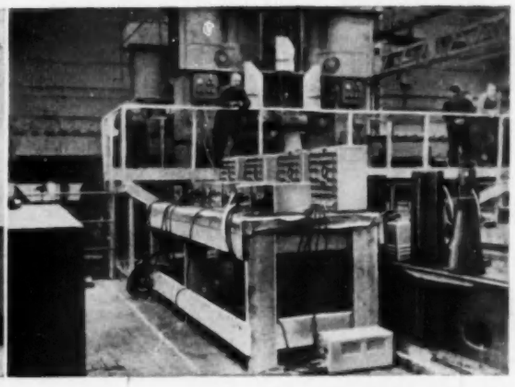
THE HEAD WRIGHTSON

COMMERCIAL STREET MIDDLESBROUGH LONDON



engineering

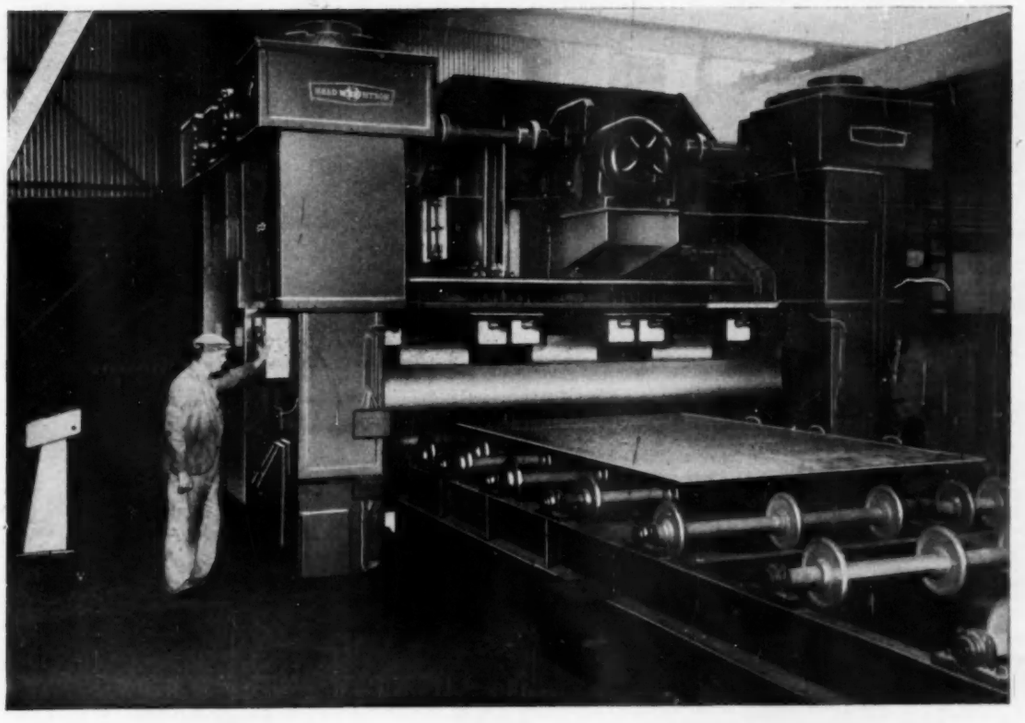




(Left) Leveller beam being machined.

(Right) The leveller undergoing fully instrumented tests prior to installation. Tests carried out with the assistance of the Group Research and Development Division.

(Below) The finished leveller installed and in operation.



Working from basic details, The Head Wrightson Machine Company Ltd. carry through the design and manufacture of capital equipment from enquiry to installation. This ability for creative engineering is well demonstrated by the Heavy Plate Leveller (to handle plates up to 2" thick by 12' 0" wide) recently installed at the Wallsend Shipyard of Messrs. Swan, Hunter & Wigham Richardson which was designed and constructed by the Head Wrightson Machine Company.

In order to build this leveller it was necessary to prepare an entirely new design in close collaboration with the Research and Development Division of the Head Wrightson Group of Companies.

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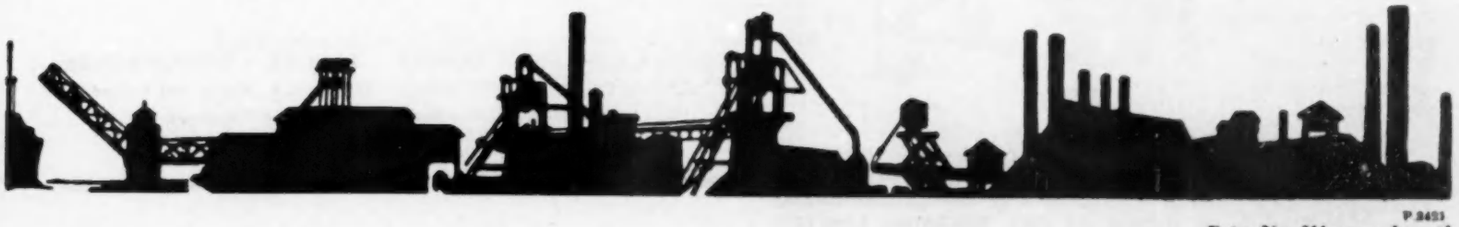

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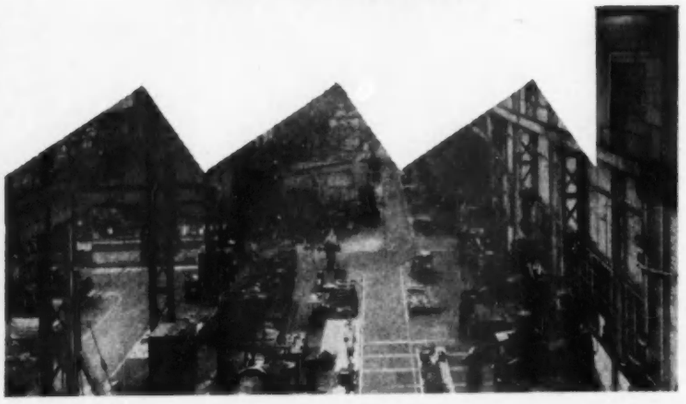
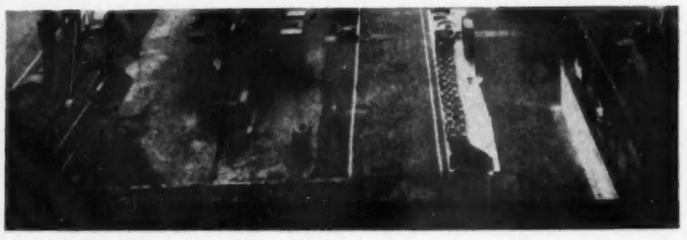
THERE'S PLANT CAPACITY AT CARRON





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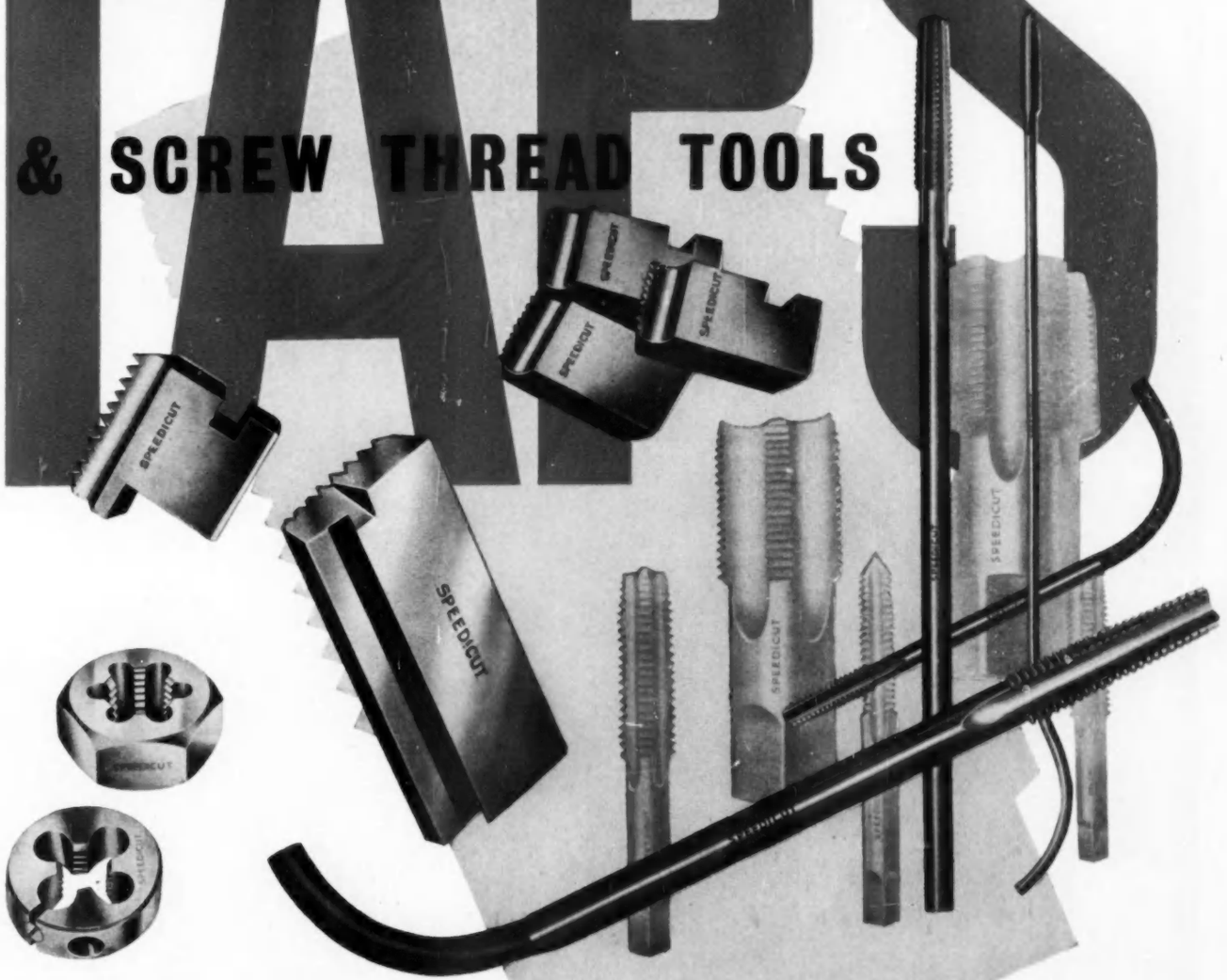

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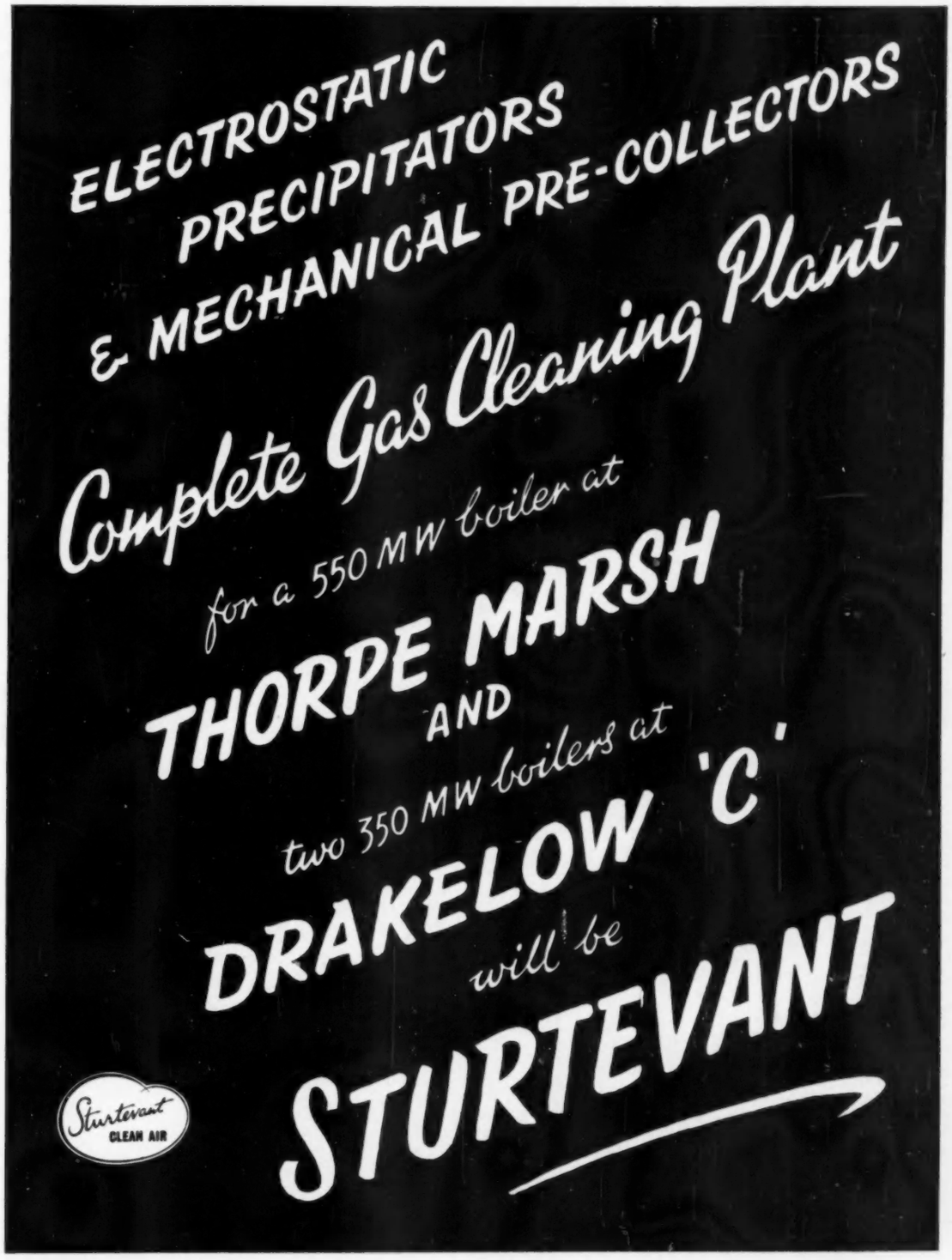

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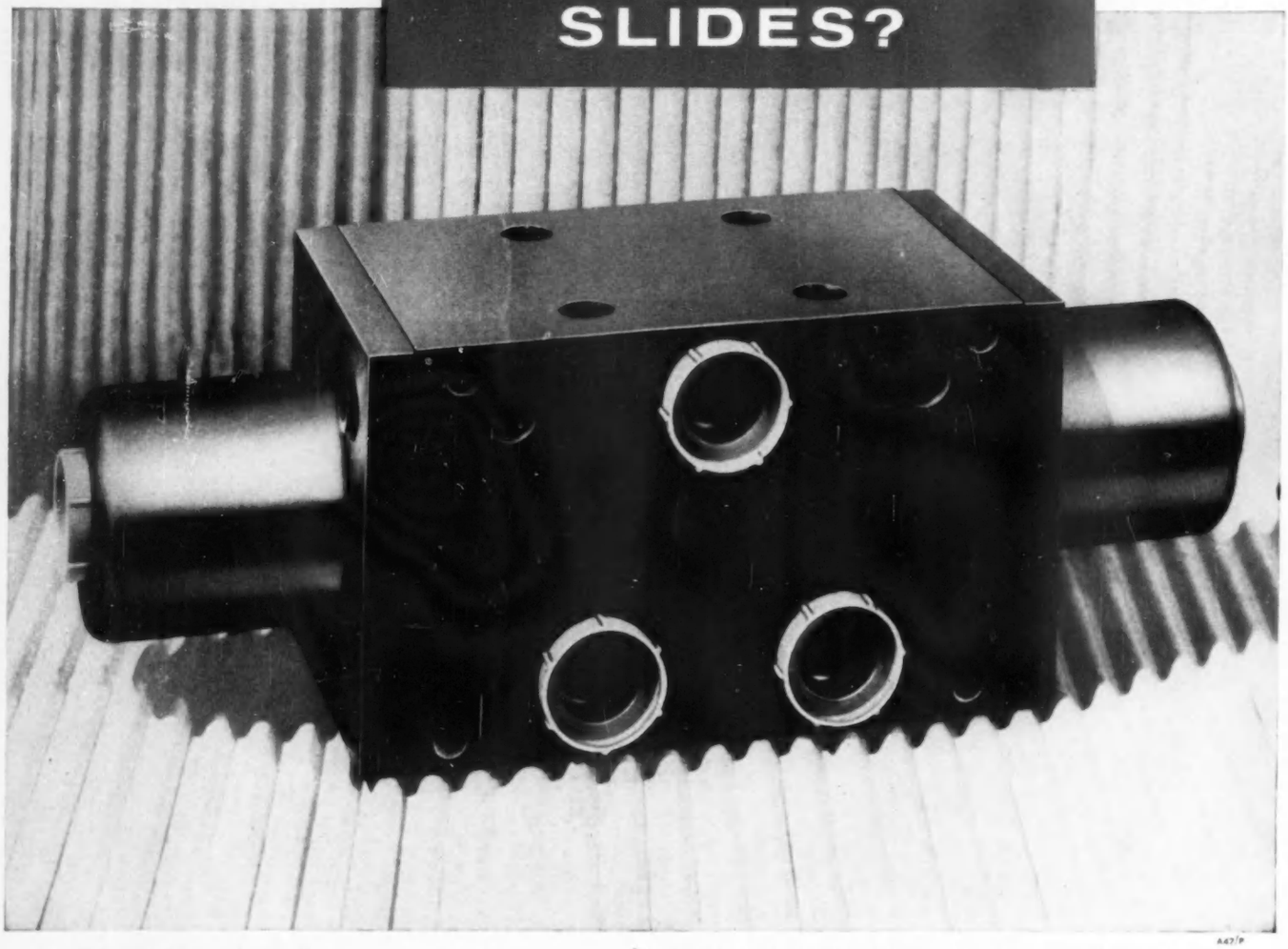
why do AIR CONTROL VALVES have RECTANGULAR SLIDES?

Patent applied for



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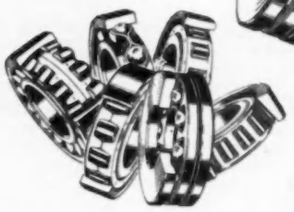
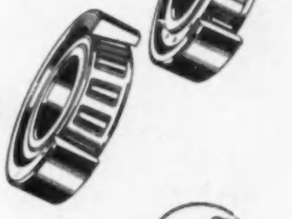
BEARINGS  **on your mind**



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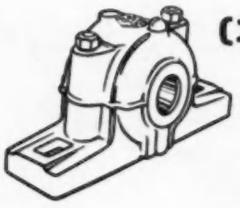

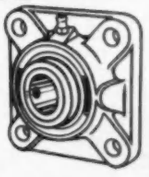

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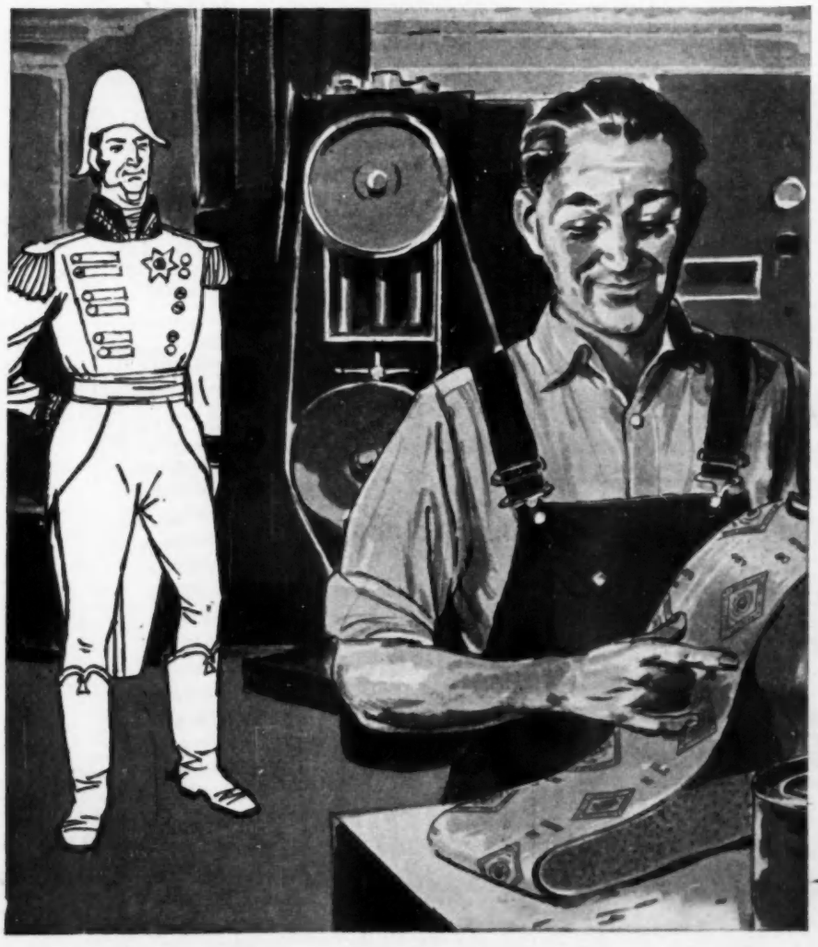

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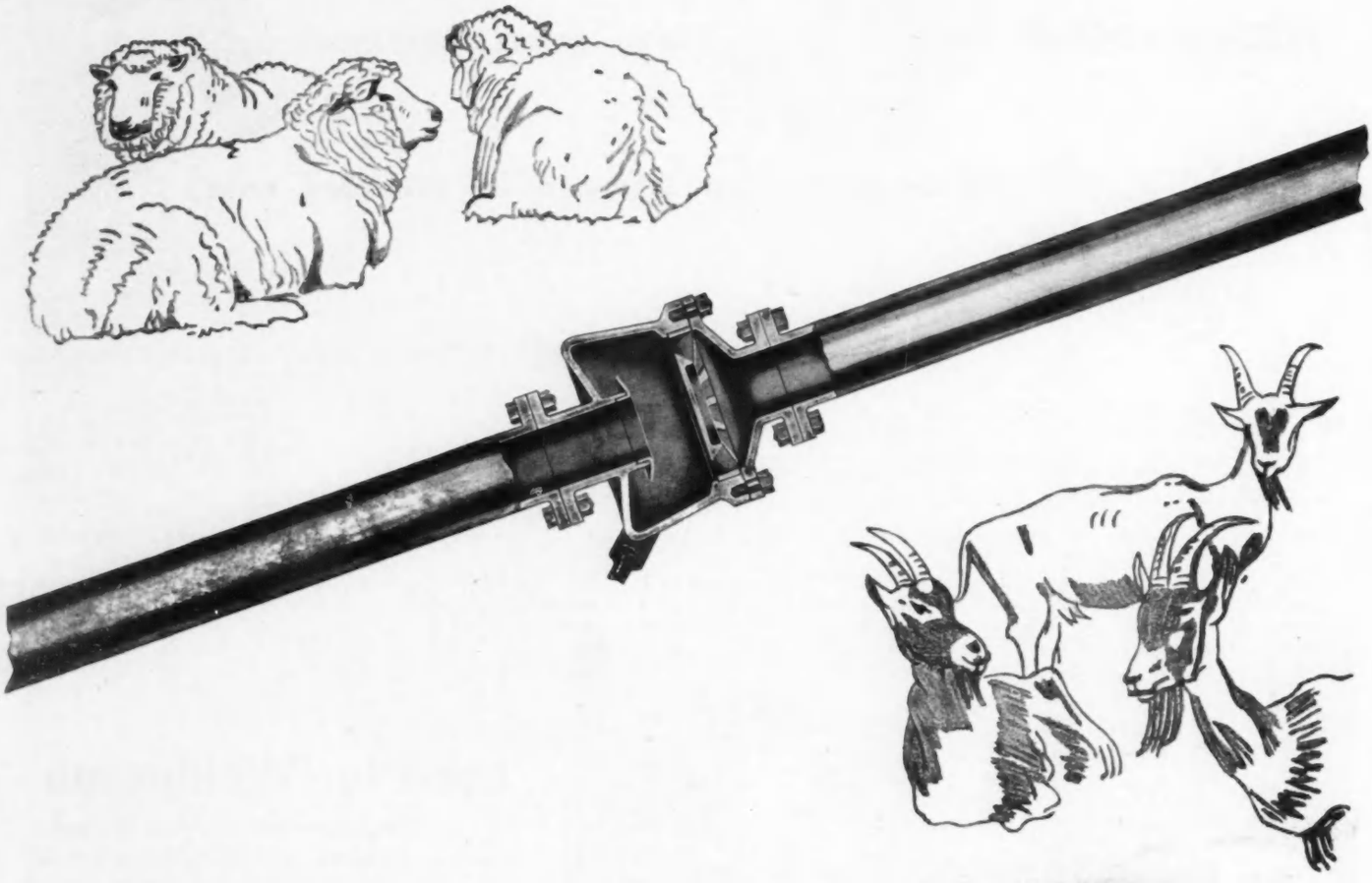

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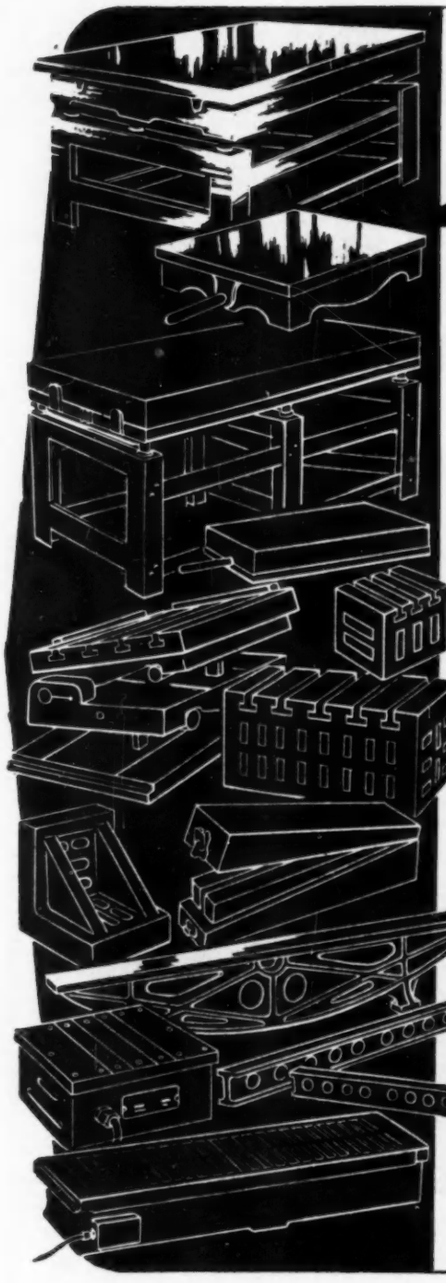

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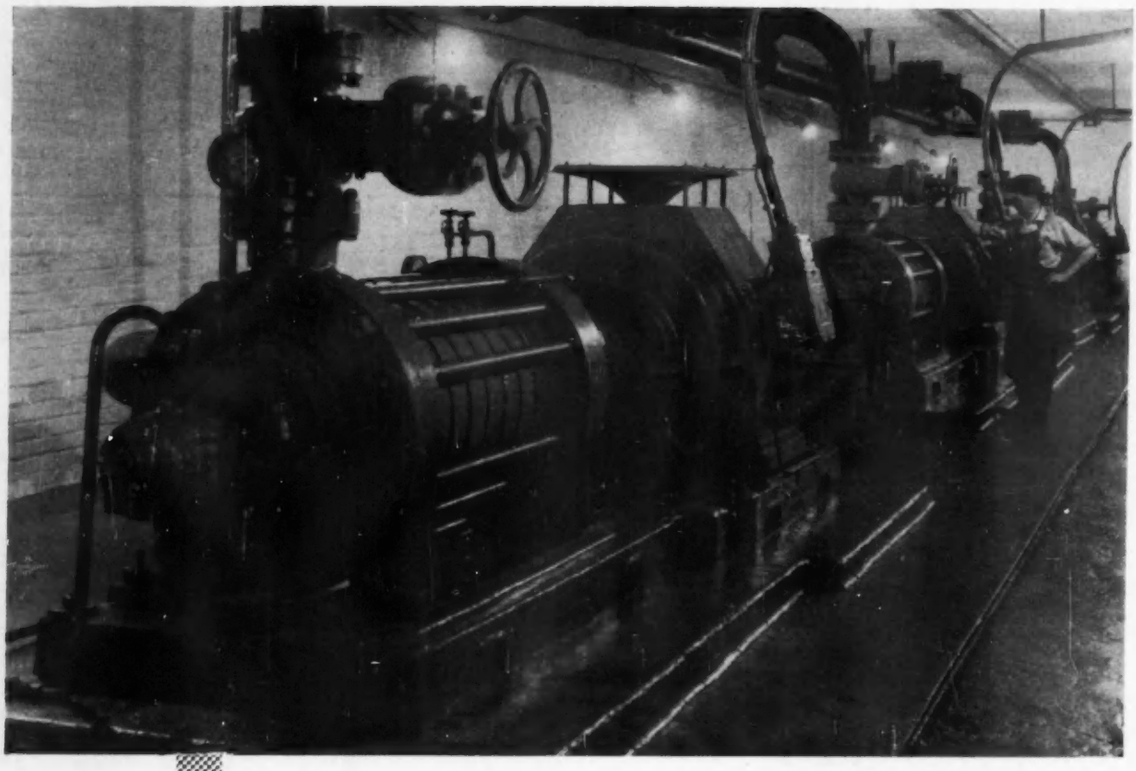

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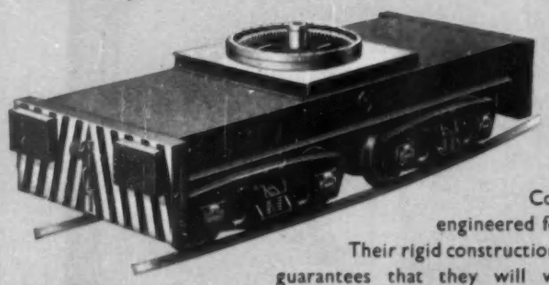

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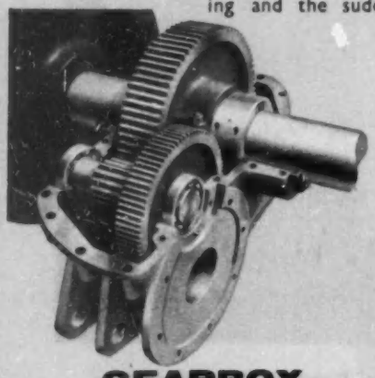
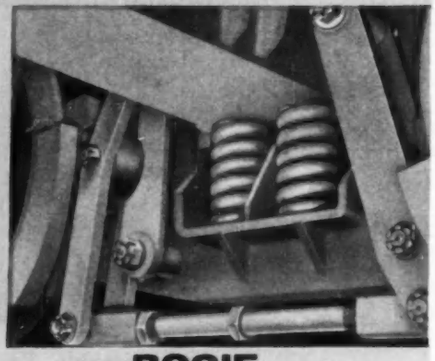


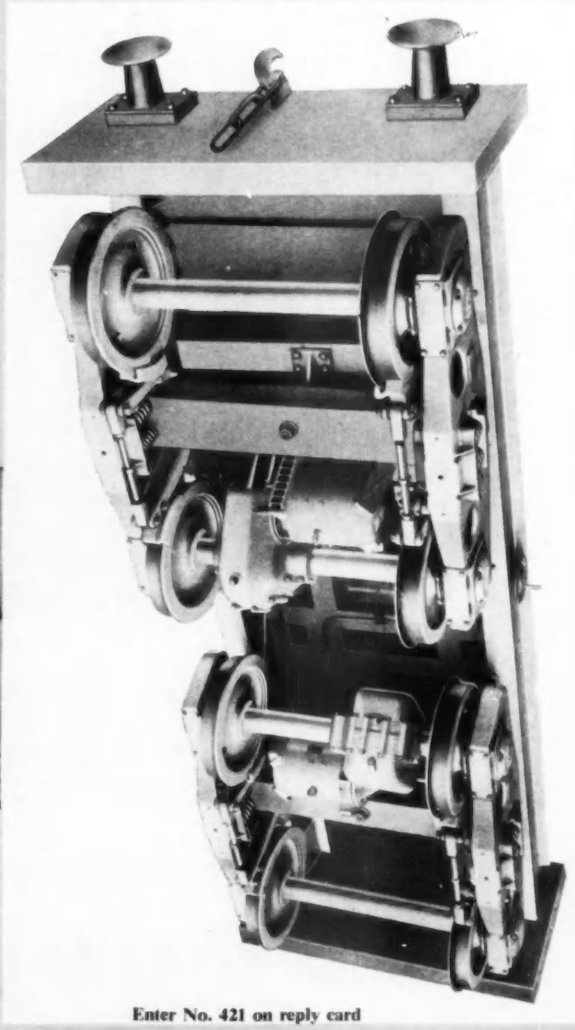
GEARBOX

All gearing is totally enclosed in cast steel gearboxes. These house accurately machine-cut steel spur gears constantly enveloped in a protective oil film, coupled to independently mounted electric motors.



BOGIE SUSPENSION

The frame is mounted on heavy-duty sprung twin bogies each having four single flange steel rail wheels and one driven axle. Robust coil springs absorb all shock loads produced by travelling over uneven track.



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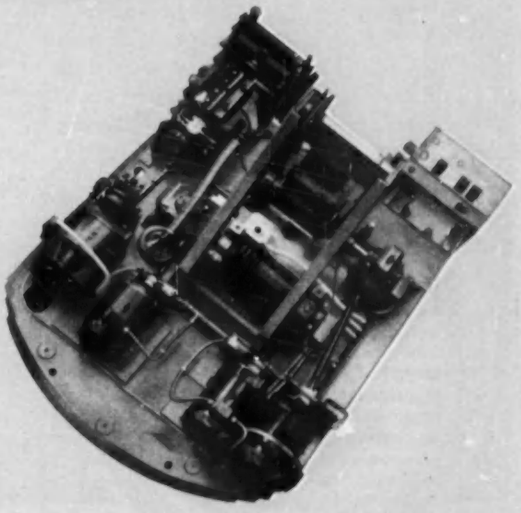
The operators cab, designed for maximum functional efficiency and comfort, provides an all-round view of the working area. Full weather protection is assured and fan or heater can be fitted to suit various climates.

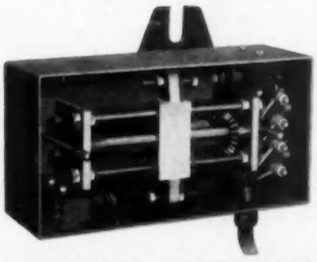


CLEAN SIMPLE LAYOUT

This clean, simple layout means ready accessibility and easy maintenance. A separate electric motor for each crane motion is powered by a variable voltage generator which is, in turn, driven by a diesel engine.

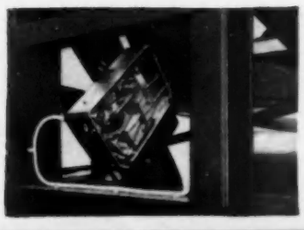
LIMIT SWITCHES

Self-resetting limit switches automatically operate should attempts be made to hoist or derrick beyond permitted limits.



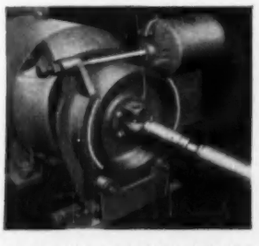
SAFE LOAD INDICATOR

Coles safe load indicator automatically prevents lifting of an unsafe load irrespective of the jib position.



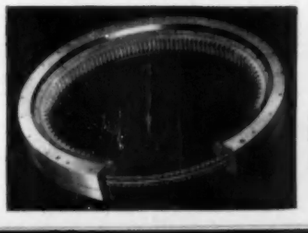
ELECTRO MECHANICAL BRAKES

Electro-mechanical brakes, fitted to all crane motions, are immediately and automatically applied should the supply of current be interrupted for any reason.



SLEW BEARING RING

The superstructure revolves on a large diameter double live ring of steel balls running in hardened races, thus obviating the need for a centre post.



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But ANDRE RUBBER limits the repercussions

FORT HALSTEAD

A 557-TON MASS of machinery and pre-stressed concrete forms part of a power hammer used by the Armament Research and Development Establishment to simulate the shock produced by the discharge of the very biggest guns.

Normally in the development of heavy artillery, proof testing is carried out on a remote range, and to have set up this very heavy plant at all in a congested area is a fact of outstanding importance to industry.

Two-Mile Radius

Using an industrial hammer of equivalent power on a conventional foundation—remembering that the 450 tons of the concrete base alone is subjected to a "kick" acceleration of 15g—the ground vibration would not only have seriously interfered with work in the test house itself and disturbed delicate instruments in nearby laboratories and workshops, but have been great enough to amount to a "nuisance" according to Acts of Parliament, at distances up to two miles from the centre of the disturbance, varying with the nature and density of the ground.

Detailed study by the Consulting Engineer, Mr. J. H. A. Crockett, B.Sc.(Eng.), A.M.I.C.E., revealed the precise nature of the shock waves, internal flexural behaviour oscillations and resultant fatigues likely to be produced by the very high local accelerations involved.

Dramatic Improvement

This led to the design and construction of a special shock-controlled foundation incorporating six special Andre Rubber Sandwich Springs, which are believed to be the largest ever used for a machine. They were developed after close co-operation between the Consulting Engineer and technicians of the Andre Rubber Company.

The degree of vibration insulation achieved (99%) is phenomenal, ground vibration becoming imperceptible at a distance of only 120 feet. This may well be without equal for such heavy plant anywhere in the industrial world.

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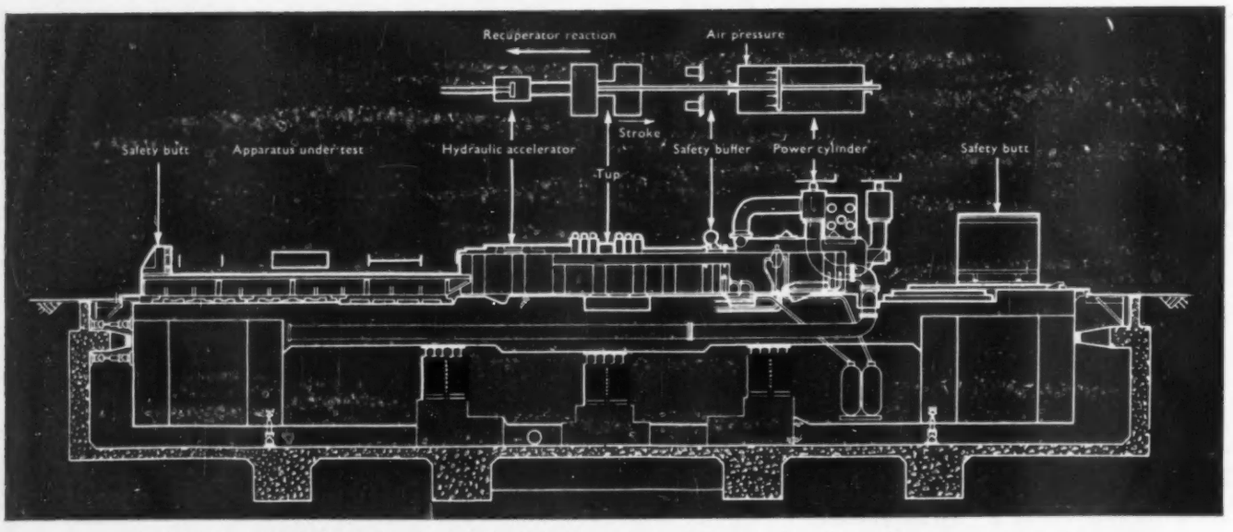
Main Rubber Spring, compressed

"Know-How"

The Fort Halstead test-hammer installations (for which some very large safety buffers were also designed) provides a typical demonstration of Andre Rubber's unrivalled experience and "know-how" in every aspect of engineering in natural and synthetic rubbers.

Many techniques that are now commonplace were pioneered and developed by the Andre Rubber Company.

Among the many heavier applications in which Andre Rubber's experience is unequalled are: railway suspension systems, harbour resilient fender systems and steel-reinforced rubber bearings for rail and road bridges.



GENERAL ARRANGEMENT OF TESTING MACHINE AND SPRING SHOCK-PROOF FOUNDATION

In this simplified drawing, the Andre Rubber Springs are shown in black

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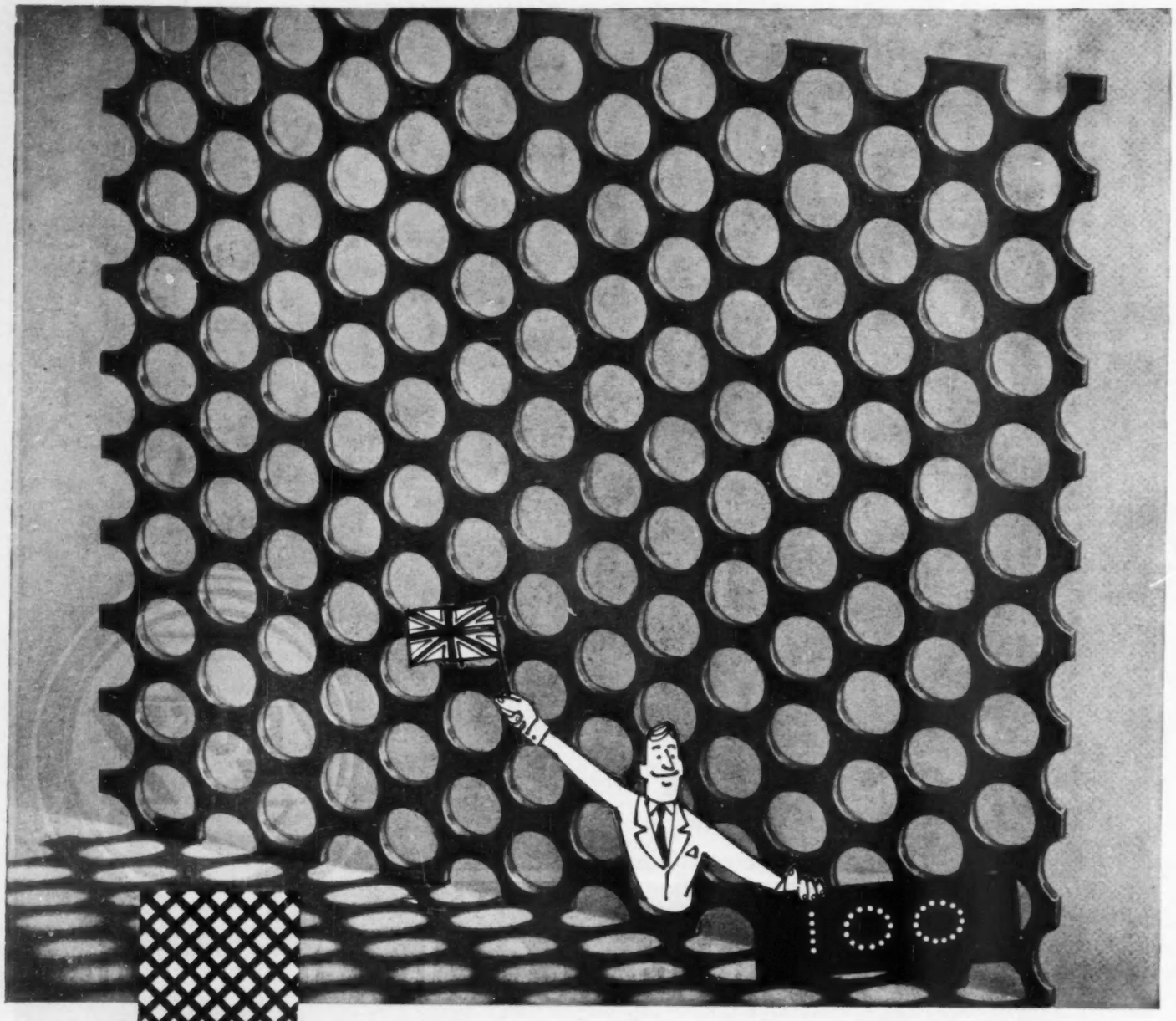

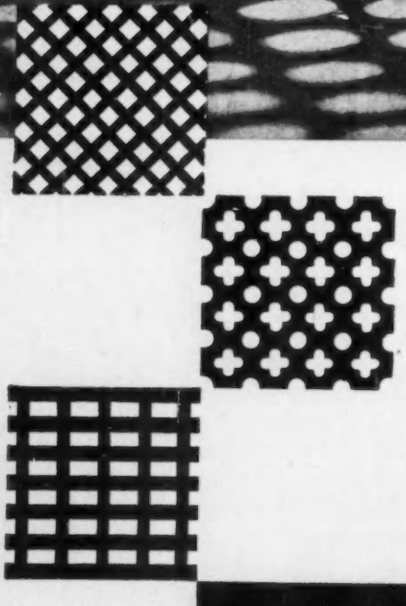

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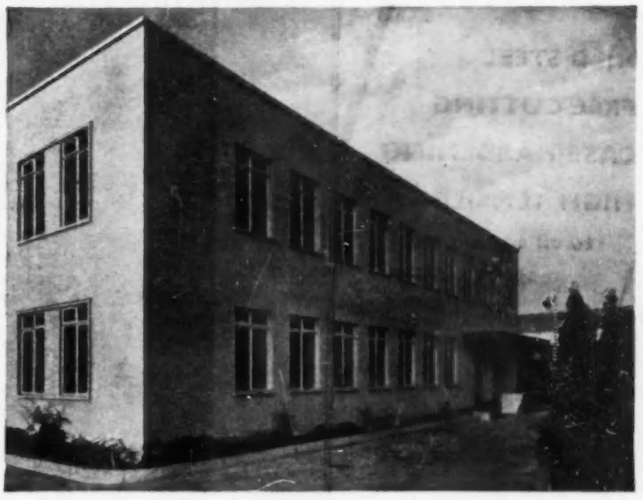

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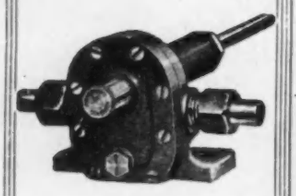

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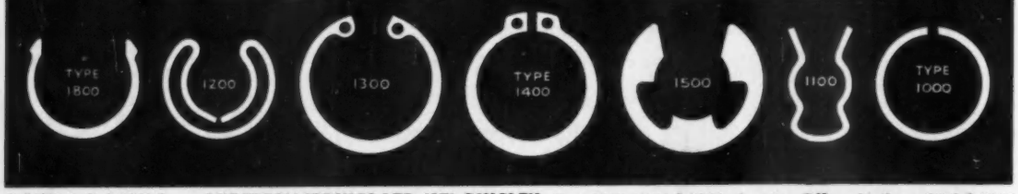

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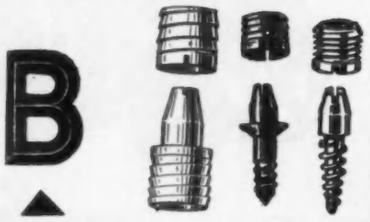

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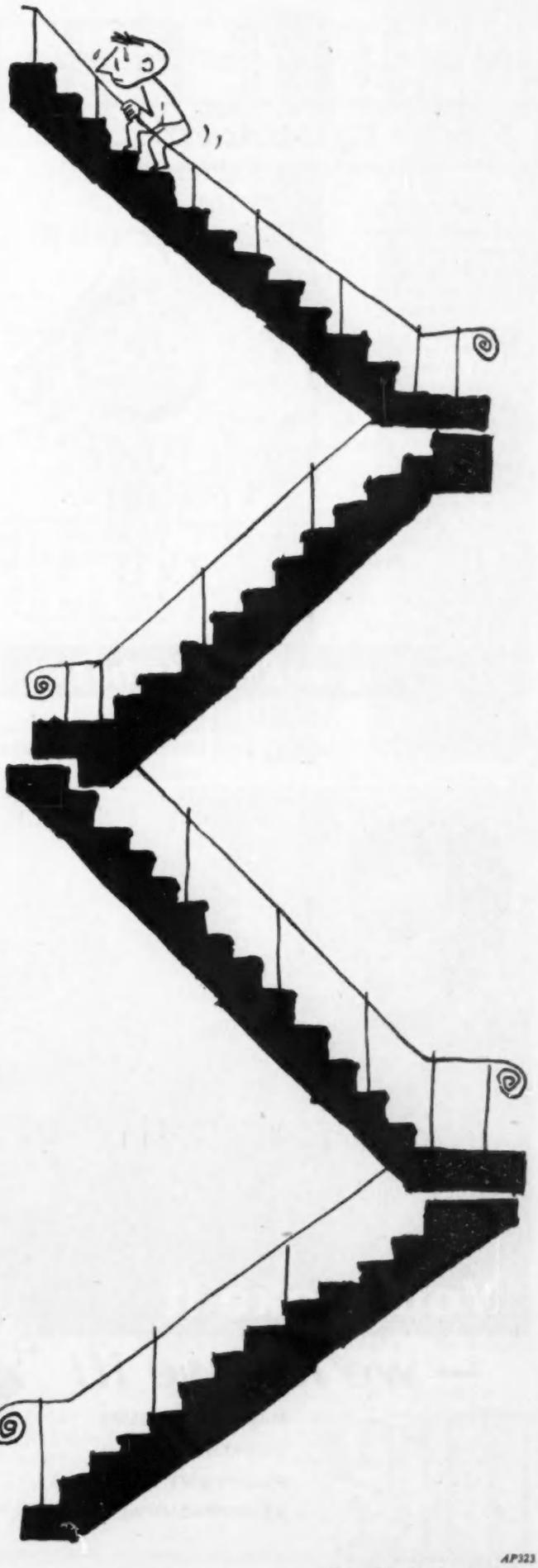

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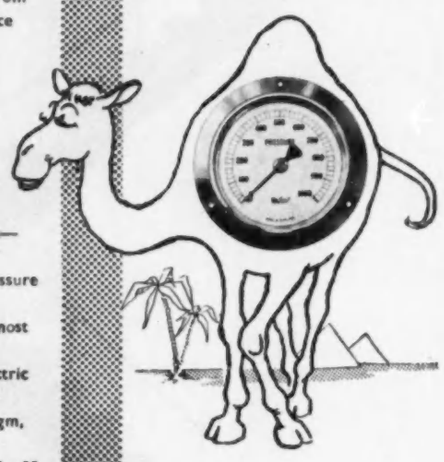

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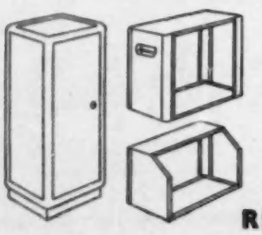

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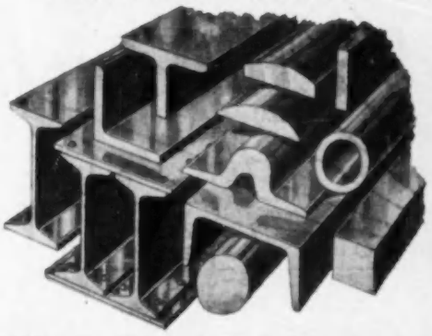

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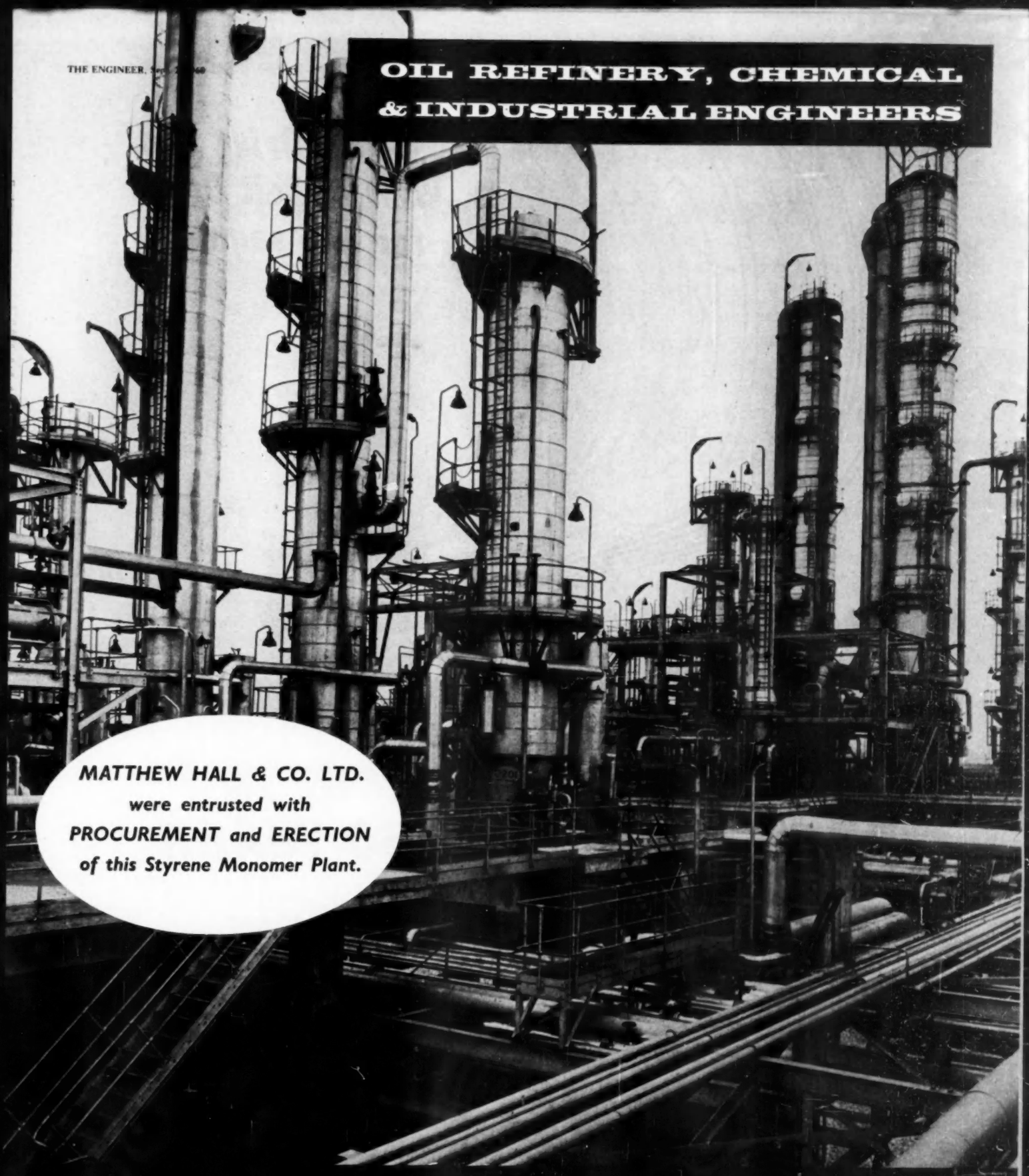

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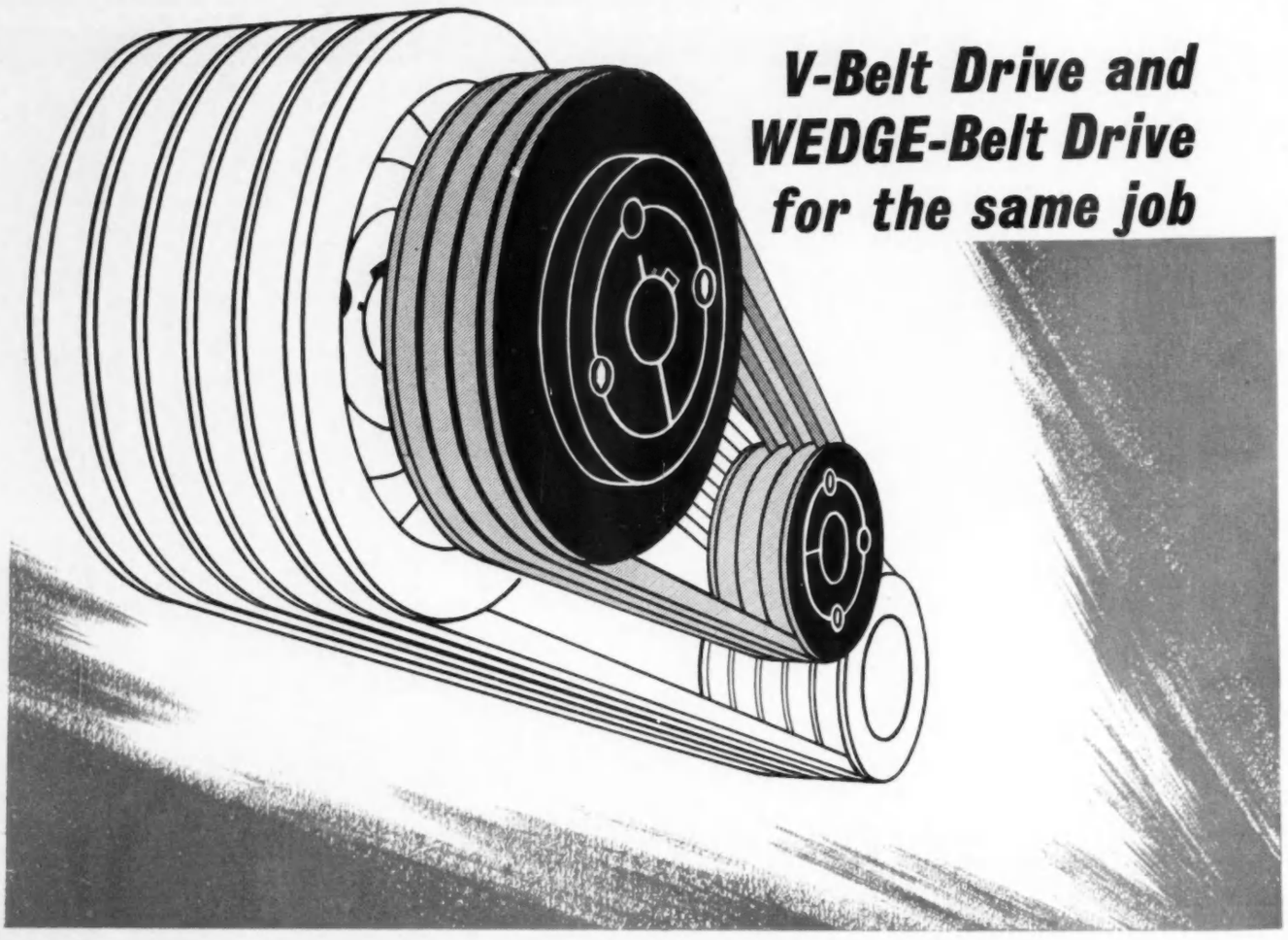

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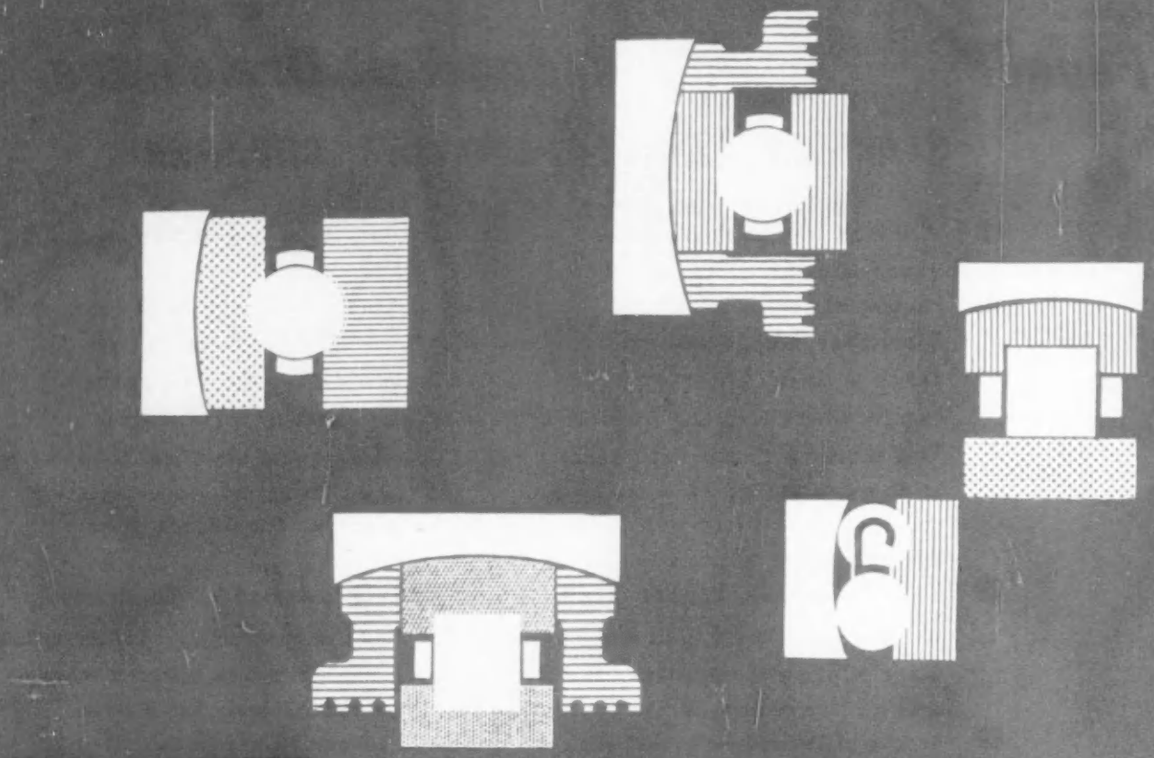

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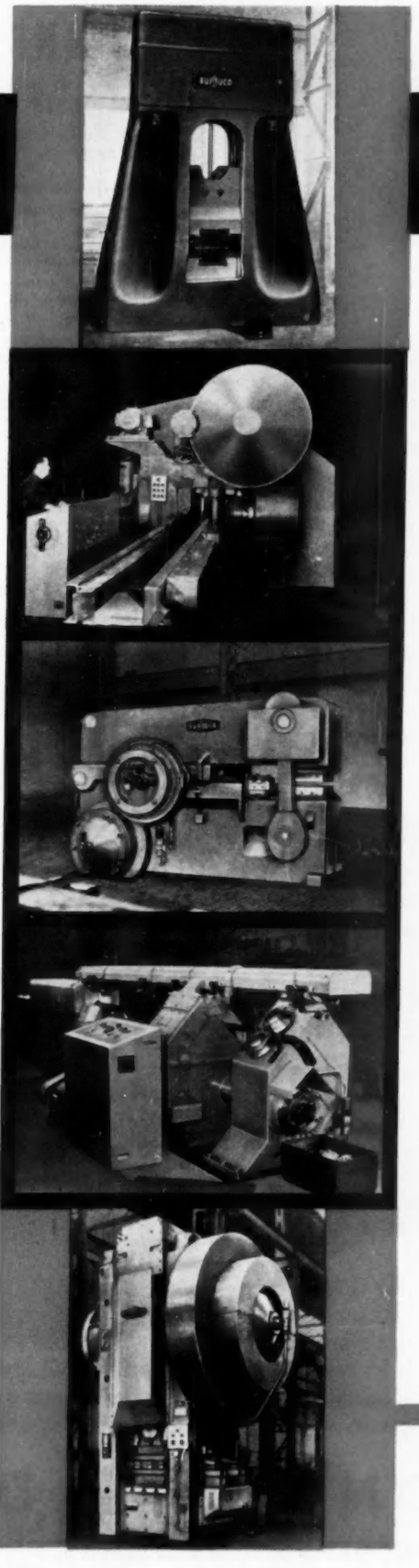

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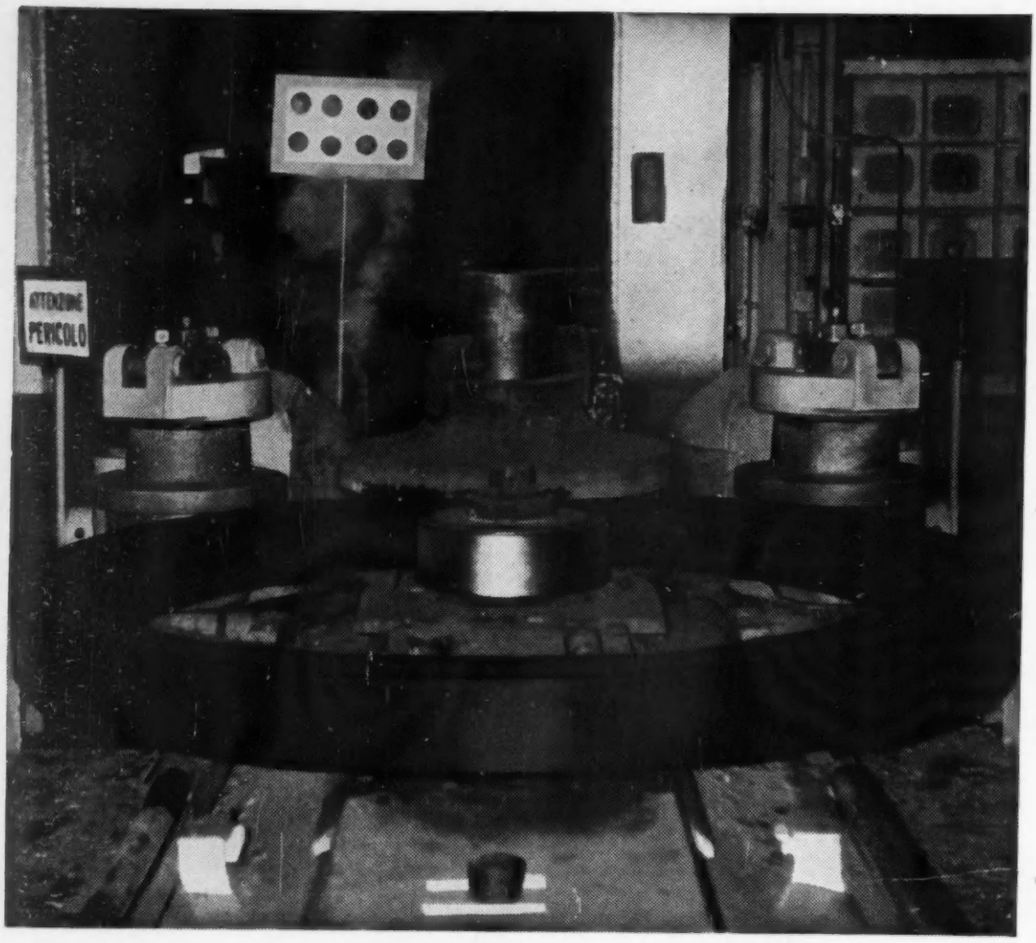

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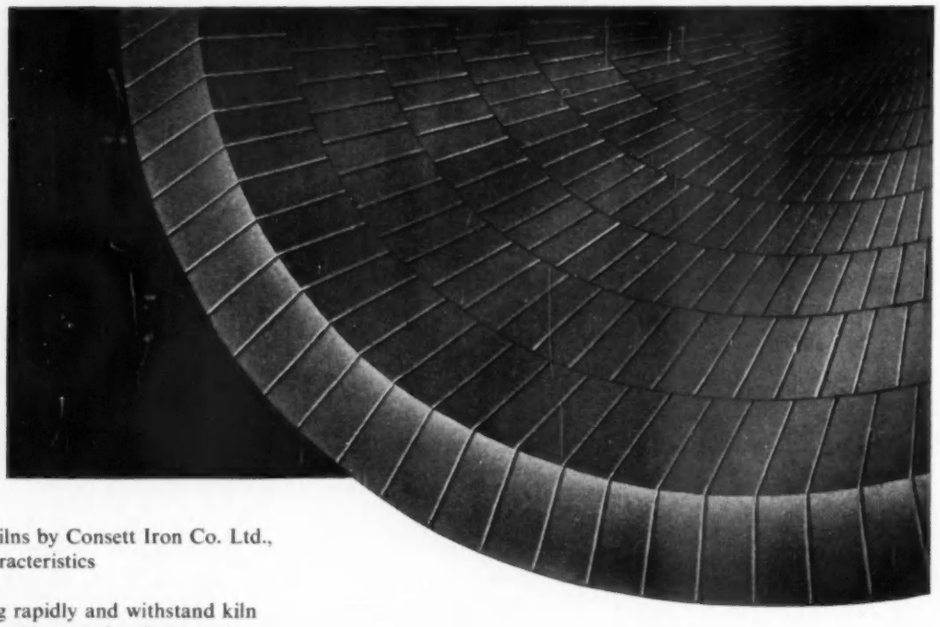

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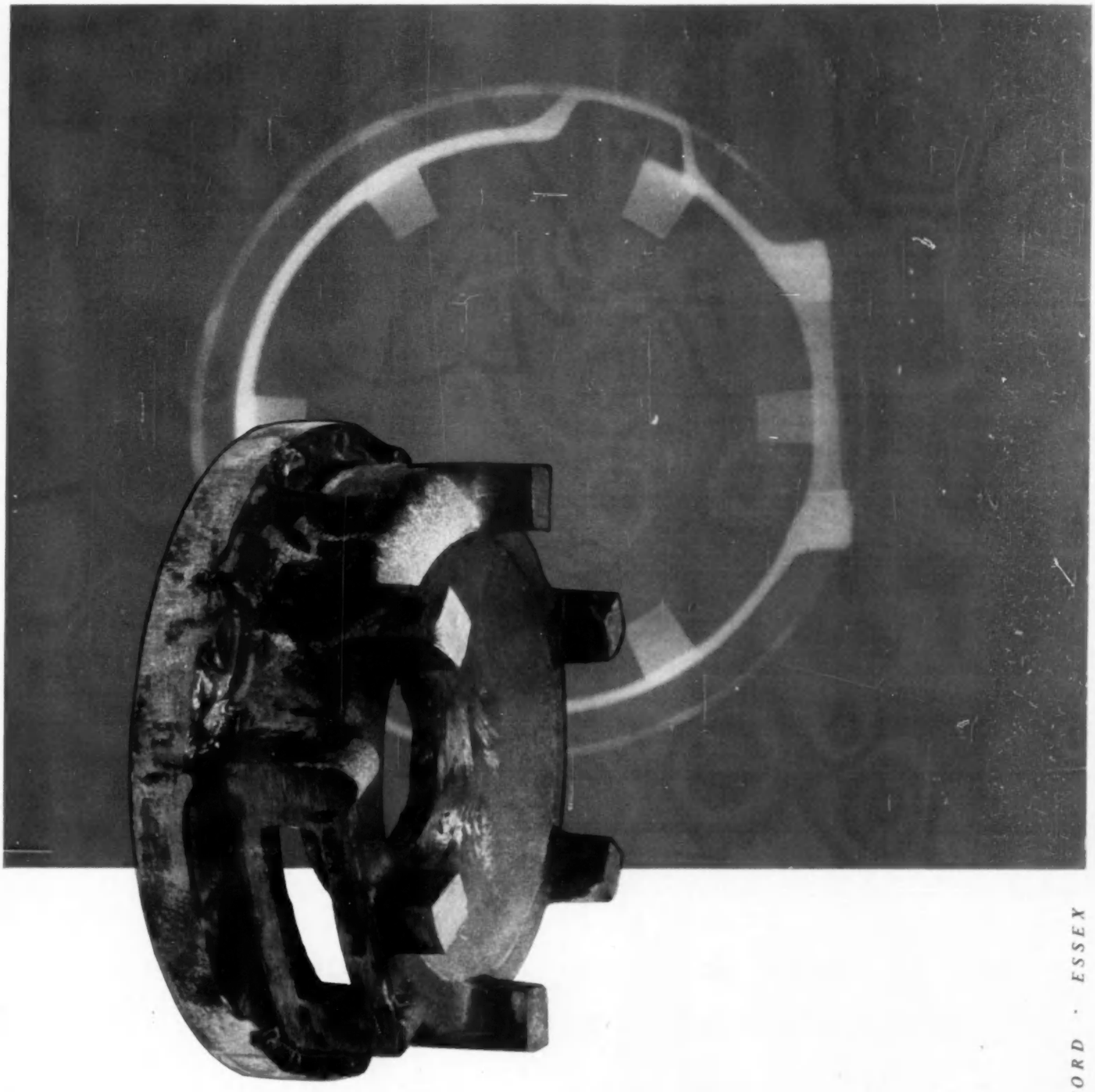

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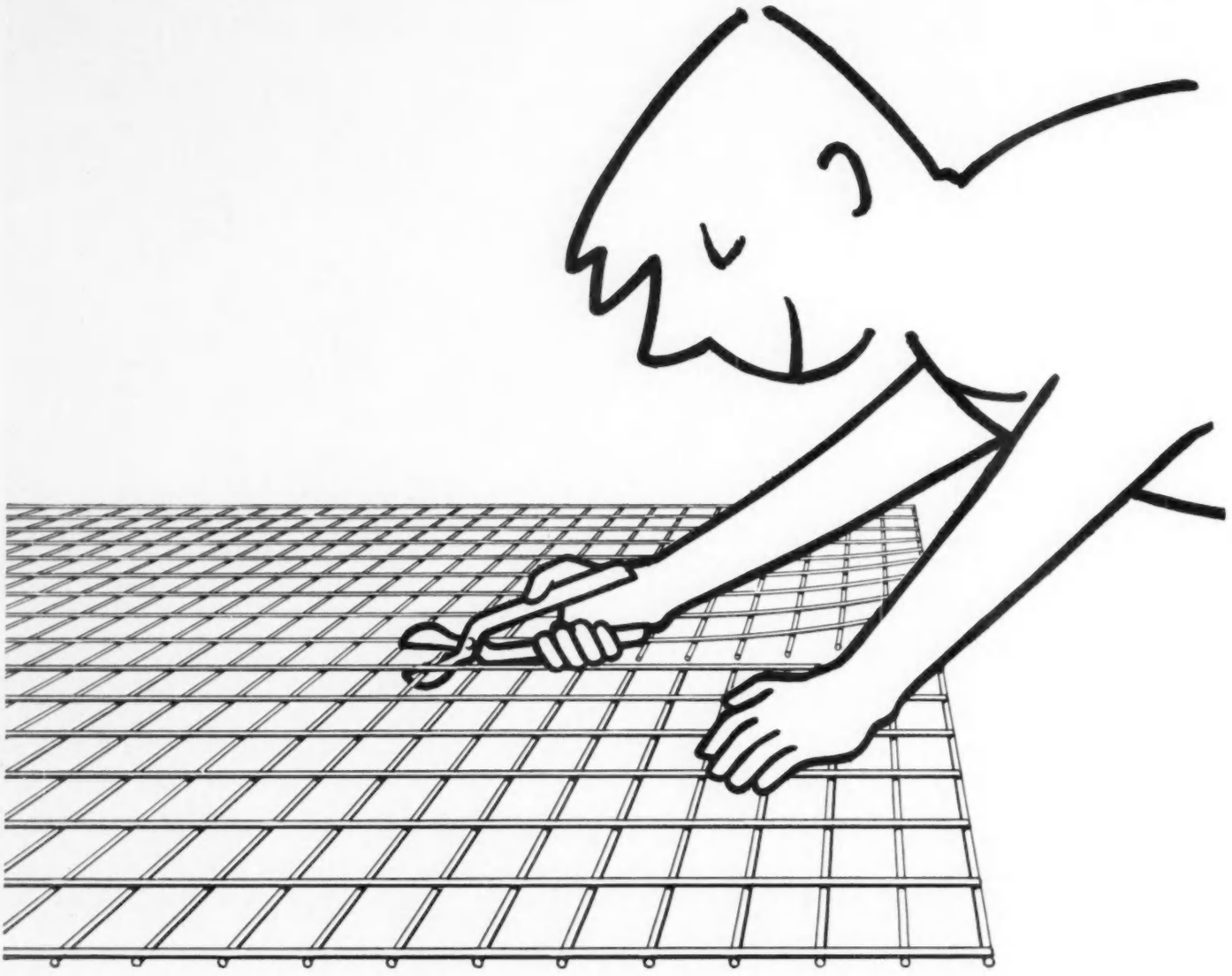

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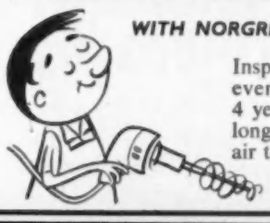

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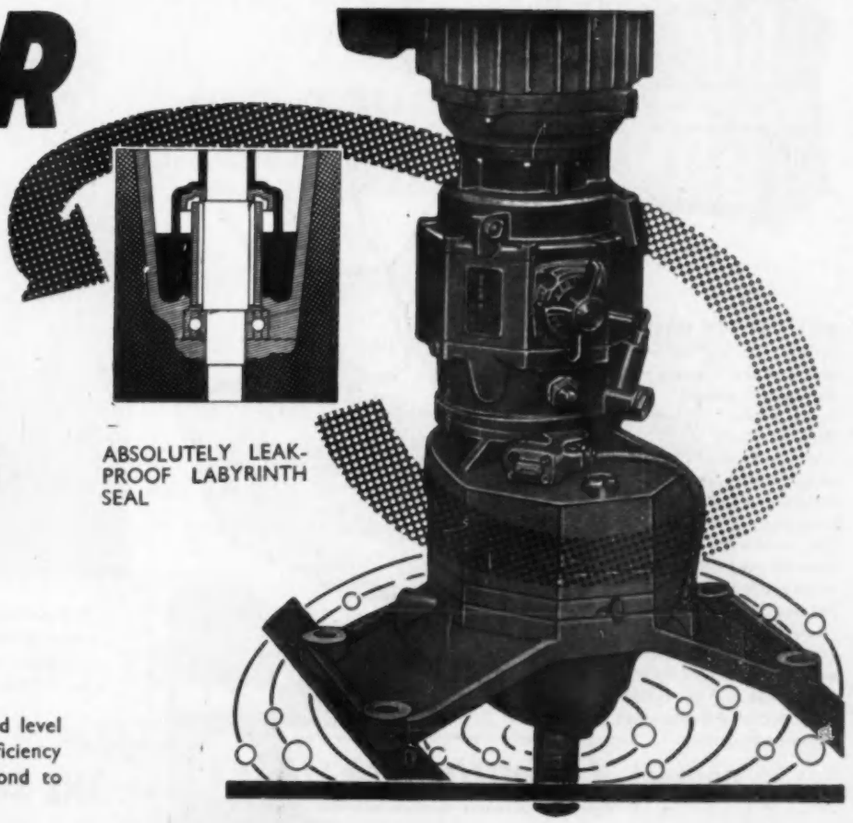

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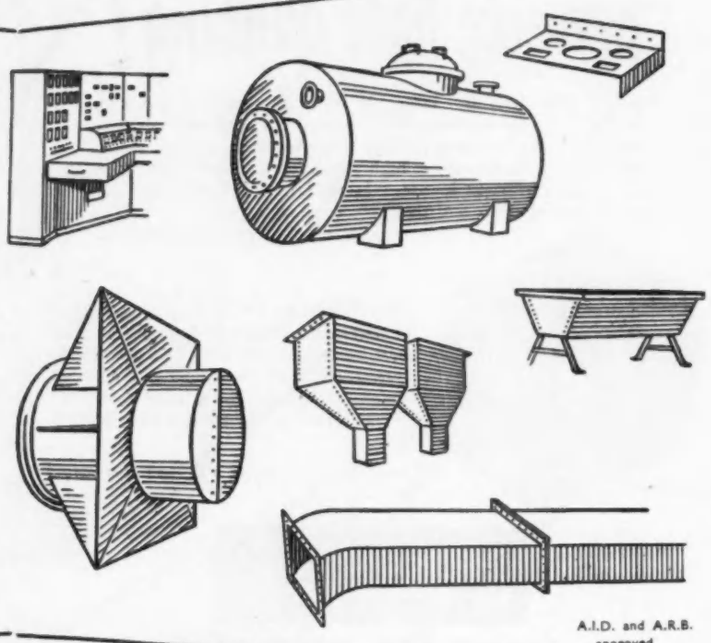

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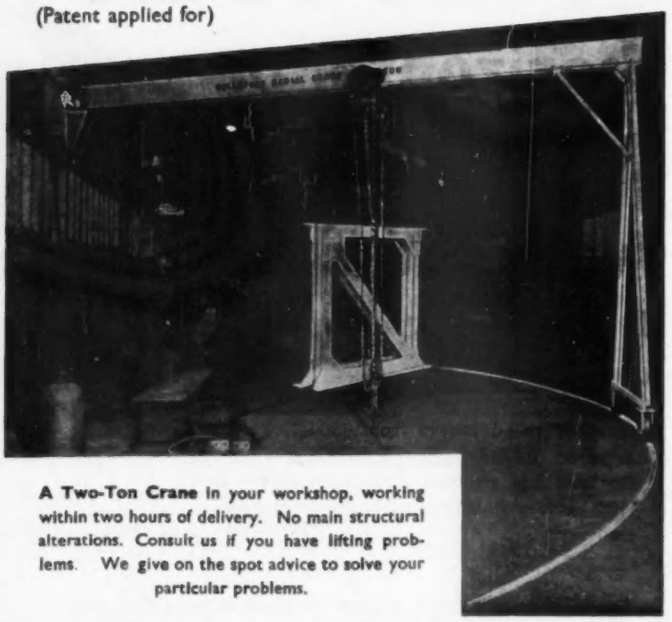

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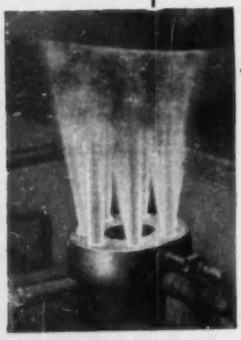

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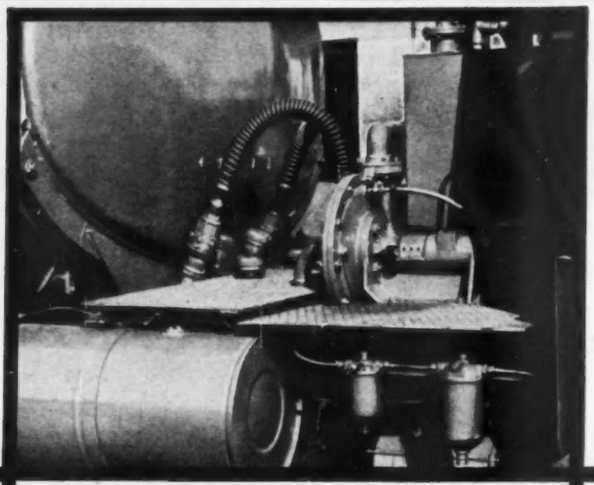

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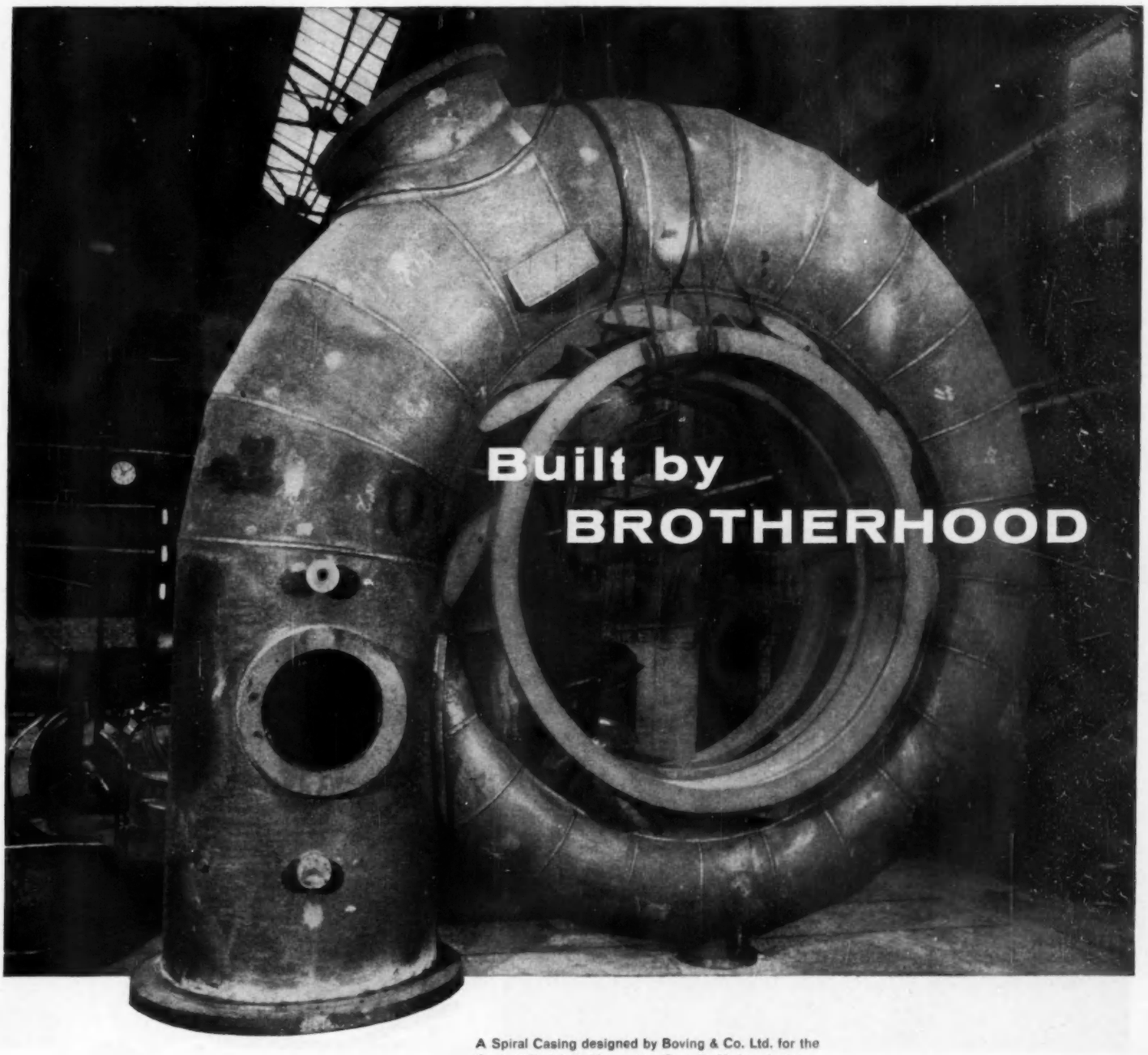

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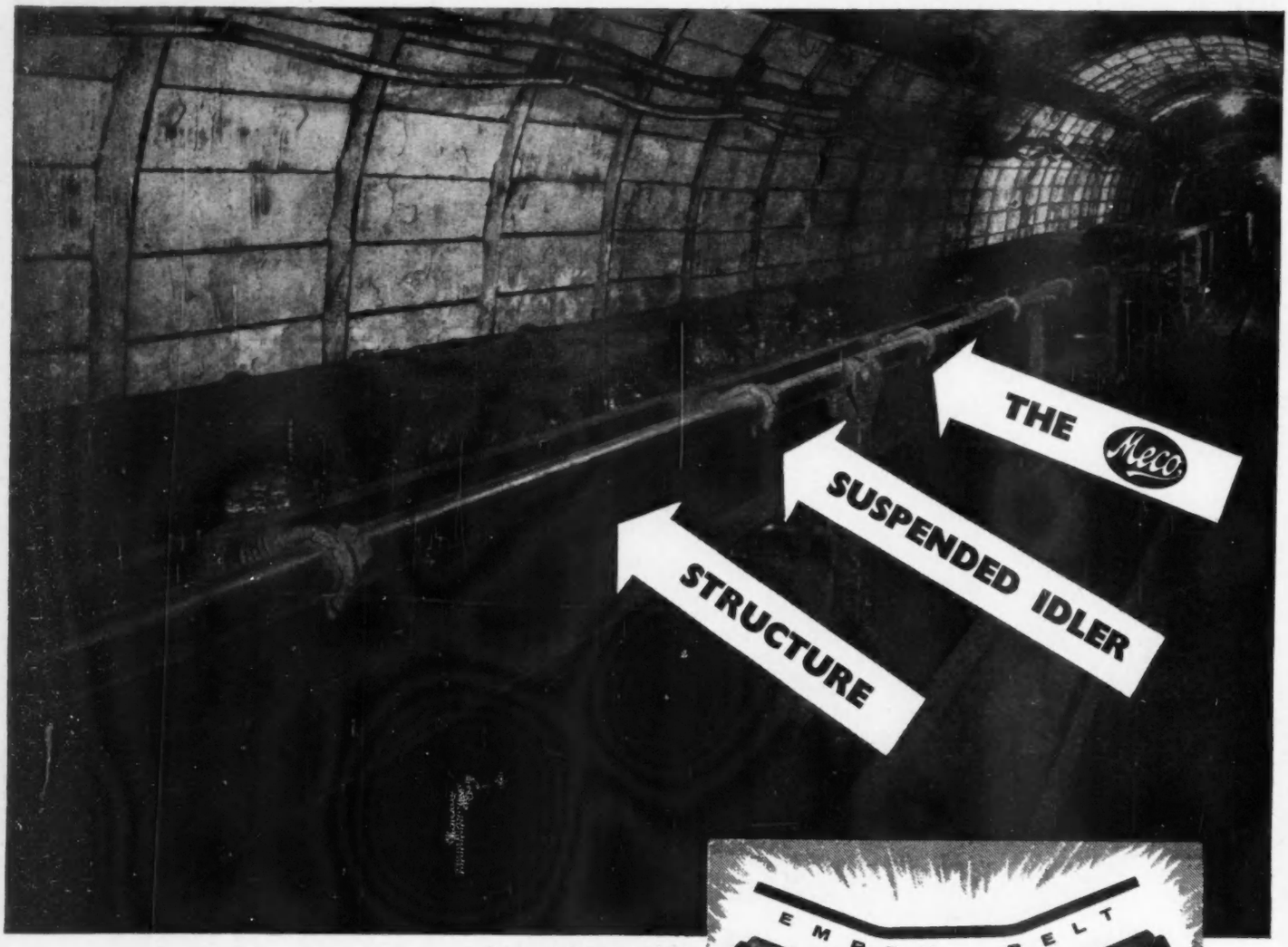

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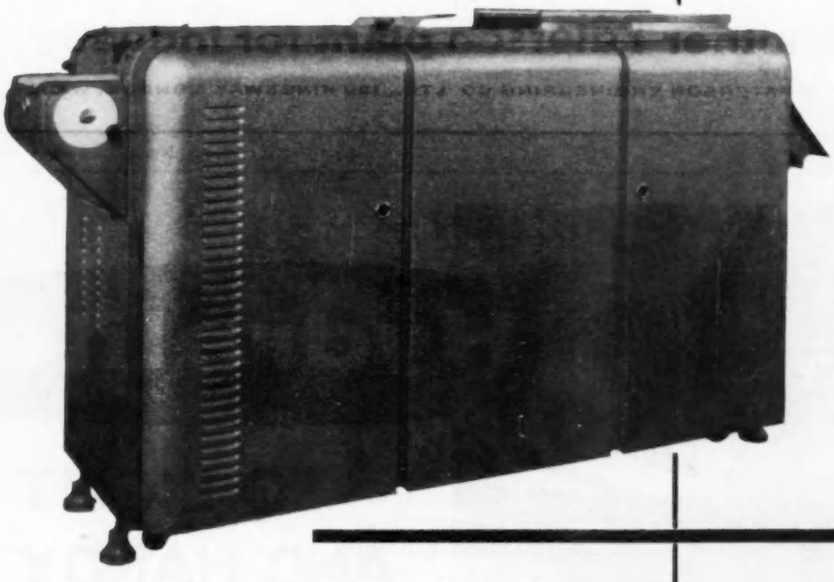

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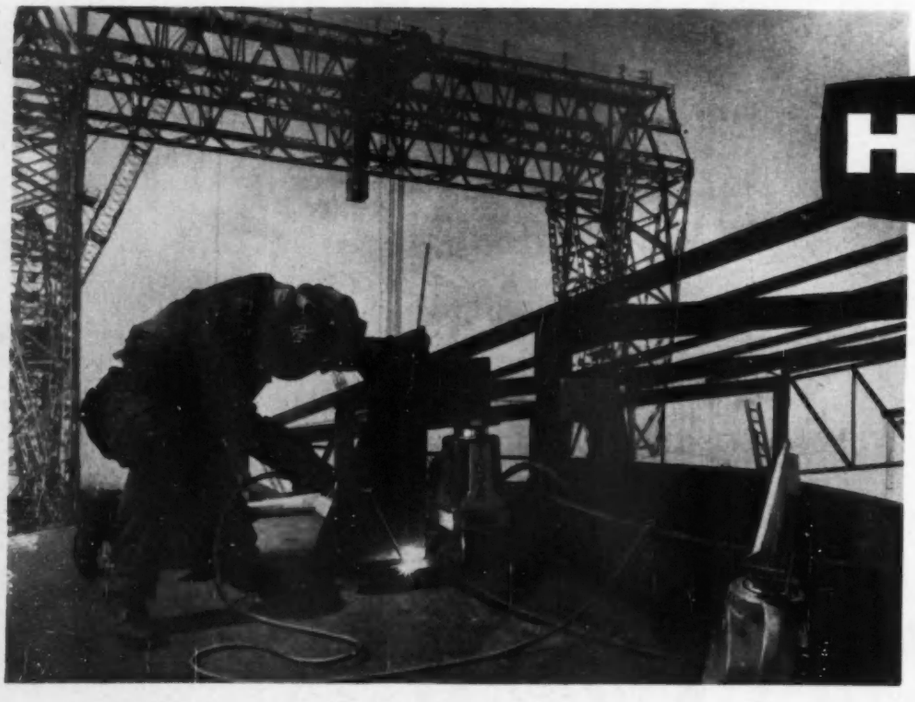

A Welder at work. An Adolf Morath picture by permission of Bradwell Nuclear Power Station and The Nuclear Power Group.

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THE ENGINEER

No. 5458 SEPTEMBER 2, 1960 Vol. 210

A SCIENTIST ON ENGINEERS

This year the British Association for the Advancement of Science is holding its annual meeting in Cardiff. To inaugurate it, as is usual, the President presented his Address. This year's President is Sir George Thomson, the Master of Corpus Christi College, Cambridge, and he took as the title of the Address which he presented last Wednesday evening "The Two Aspects of Science." We do not reproduce very much of the Address because he spoke mostly as a physicist. But in the earlier part of it he had, as a scientist, quite a lot to say about the application of science, which delighted engineers amongst his audience. For engineers, practical as they are, still feel convinced that their work must have value even for people whose work lies in the more rarified regions of science. Here was a scientist showing himself well aware of it. "To me science without technology is incomplete and inconclusive. Systems of philosophy come and go, some are perhaps true but who can tell? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms." Those words concluded a section of the Address which contained such words as "Is there not a danger that one may lose touch with reality, and end by supposing that some elaborate piece of mathematics represents reality, when it is only a creation of the mind, inspired indeed by physical reality but no more like it than a modern picture?"

Other sections of the earlier part of the Address proved interesting to engineers too. Sir George stressed, for example, that the best way to make advances in a technology is to understand the principles. It is worth remembering that a hundred years ago almost all engineering design was based on "good practice" and it was very largely in the practical art and through the process of trial and error that advances were made. As Sir George put it "Increasingly more discoveries are made in research laboratories and fewer by workmen on the bench." A hundred years ago engineering was predominantly learnt in the works, or, for civil engineers, on the works. And it was in or on the works, through the improvement of craft skills and workshop devices, permitting thereby improvements in design of machinery, that engineers could expect to make their mark. It was really needful that an engineer should acquire handicraft skill in order that he should be able to improve upon the craft, as then known. But nowadays it can be said of most engineers that their contribution to the technology should be the application of fundamental principles to design, to the solution of practical problems, and to the organisation of work. It is coming to be asked, is the acquirement of handicraft skill any longer really necessary?

ESTUARIAL CLEAN-UP

On September 29 the Clean Rivers (Estuaries and Tidal Waters) Act will come into operation. What that Act does is to make some provisions of the Rivers (Prevention of Pollution) Act of 1951 apply to estuaries and to certain closely defined tidal waters. Under the new Act anyone wishing to bring into use any new or altered outlet for the discharge of trade sewage effluent into what are now to be termed "controlled waters" is required to get a river board's consent, and the board can impose conditions as to the nature and rate of discharge of the effluent, &c. But much though we would like to think that the coming into force of the Act will indicate that a really significant start has been made towards cleaning up estuaries in England and Wales, we do not think so. For two things need to be noted. First, the board's new powers relate only to new or altered outlets, so that anyone polluting an estuary can continue to do so with impunity; and, secondly, the consent of a river board is not required by a local authority discharging sewage into an estuary, provided the necessary works have been approved by the Minister. In several estuaries, notably that of the Tyne, the discharge of domestic sewage is probably at least as important a factor in polluting the waters as is the discharge of industrial wastes. But for political reasons one must suspect that the Minister is likely to be more lenient in giving approval to the discharge of domestic raw effluents than the river board would be. Indeed, a Circular which has just gone out from the Ministry of Housing and Local Government exhibits a certain nervousness on the part of the Ministry about the use river boards may make of their powers. "Although some river boards have carried out extensive surveys of non-tidal streams their knowledge of tidal estuaries, particularly of the rates of flow there, will often be less complete. It is suggested, therefore, that, until river boards have considerable experience of the waters concerned, they should have special regard to their power under . . . the Act of 1951 to vary conditions attached to consents. Conditions imposed with the warning that they are subject to review and that in the light of experience they may have to be made more stringent, perhaps within a specified period, are in the Minister's view fairer to the applicant than rigid precautionary conditions which fuller knowledge may show to be unnecessary." Since industrial firms having effluents difficult to treat have effectively been encouraged in the past to site their works where the discharge could be to estuarial waters those remarks of the Minister can be commended. Industry should be persuaded to co-operate in cleaning up estuaries rather than be compelled to. But the remarks also must make one wonder whether persuading the Minister to co-operate may not prove the bigger obstacle to rapid progress! For until progress is made in preventing the discharge of raw domestic sewage into estuaries industry can hardly be expected to prove enthusiastic in providing treatment plant for its own dis-

charges. It remains to be seen how effective the Ministry will prove itself to be in inducing local authorities to undertake expensive sewerage schemes and to build treatment works. How much obstruction will there be from the Treasury?

U.S.S. "ENTERPRISE"

The U.S. nuclear powered aircraft carrier "Enterprise" which is to be launched next month will be the largest warship in the world and is one of the first of the prototype surface ships of the new American nuclear powered Navy. It is significant also that she is being constructed with the knowledge that deterrent submarines are being built concurrently to launch sixteen "Polaris" rockets while submerged. When in the early 1950's it became clear that Russia had learnt the secrets of the atomic bomb, the U.S. Government decided that the land-based bombers of their Strategic Air Command should be supplemented with carrier-based bombers with a range of 2000 miles. Concurrently with the development of the medium range A3D "Skywarrior" naval bombers, the construction was commenced of "Forrestal" class supercarriers of 60,000 tons required to operate them. By the end of next year, seven of these vessels will have been completed, including the 75,700-ton "Enterprise," which is nearly 16,000 tons heavier than the remaining six vessels of her type because of her nuclear power plant. Despite the American claim that they are the logical outcome of the heavier jet aircraft since the war, their primary task is to operate heavy medium range deterrent bombers and it is for this reason alone that supercarriers are required. It seems moreover that the United States naval authorities are satisfied that these large vessels can be given adequate protection against aircraft and submarine attack, since the U.S. naval authorities asked for funds in this year's budget to build yet another carrier similar to the "Enterprise." The request was turned down, presumably on the grounds of expense.

The "Enterprise" is to cost £155 million compared with the £70,000,000 "Forrestal" type. The advantage of nuclear propulsion for surface ships lies, however, mainly in prolonged endurance—both the "Enterprise" and "Forrestal" are 33-knot ships—and the decision to adopt the air launched ballistic rocket "Skybolt" suggests that the United States may find the "Forrestal" type carrier a much less costly deterrent base than the £40,000,000 submarine. American bombers have been relying on the air-launched guided flying bomb "Hound Dog" with a range of 500 miles. But it is now becoming clear that any large air-breathing guided missile travelling at relatively low speeds within the atmosphere and depending on radio guidance will no longer be safe from anti-aircraft measures. Hence the new lease of life given to the bomber—whether land-based or carrier-based—by the "Skybolt" with its trajectory in free fall. With her flight deck area of 4 acres, a "Forrestal" carrier launching 100 bombers has a deterrent power equivalent to six "Polaris" submarines costing a total of £240 million. Whether or not the Americans continue to build deterrent carriers, these astronomical sums for ships primarily required for deterrent purposes are quite impracticable for Britain with a defence budget of £1500 million. None the less the "Skybolt" will do much to solve Britain's defence problem. She will, in fact, be able to revert to her pre-1957 defence policy of paying more attention to conventional forces while strengthening the Allied deterrent with an annual addition to our V-bomber force. If there is a risk of some bombers being caught on the ground by surprise attack, the growing realisation that a suicidal total war in Europe is out of the question surely justifies disregarding it.

Is there, then, any role for aircraft carriers, apart from these huge American deterrent vessels? Britain certainly has need of them to enable the Royal Navy to carry out its primary deterrent role of preventing a "brush-fire" campaign overseas from developing into a more serious conflict. This must be done quickly if it is to be effective. Air transport can move troops, but they can only be sustained and provided with heavy equipment by sea. Air cover will also be required until R.A.F. bases can be established ashore. Two British 22,000-ton carriers—the "Bulwark" and "Albion", which each cost £10,500,000—have been, or are being, converted to land a Commando force of 600 Royal Marines by helicopter to ensure troops arriving in a disputed area in the shortest possible time. This leaves the Royal Navy with only five carriers—"Ark Royal," "Eagle," "Victorious," "Hermes," and "Centaur"—to operate reconnaissance and strike aircraft. All seven vessels were laid down during the war and must in due course be replaced if a "brush-fire" campaign is to be dealt with promptly. Whether it will be necessary to add to the number will depend on the kind of war which is visualised. Russia has now a clear cut foreign policy of absorbing the under-developed countries within her orbit and the size of her Navy suggests she is prepared for maritime operations on a large scale—short of total war in Europe—if other nations attempt to interfere. The reconnaissance function of the carrier would in that event become of the greatest importance in the defence of the sea routes.

SCIENTIFIC RESEARCH IS THE YEAST OF BUSINESS

A few days ago there died in Hawaii Dr. C. E. K. Mees, who spent a lifetime in studying and conducting research into photographic processes. He was an Englishman and his early work was done in this country. But shortly before the first world war, upon joining the Kodak Company, he went across the Atlantic to make his life in the U.S.A. After that war he became director of research and development for the Kodak Company. Dr. Mees, it will be appreciated, cannot be termed an engineer; he was a scientist. But he must be counted amongst the select band of scientists and inventors who have combined deep technical insight with an appreciation of business factors. His aim in his work was not so much to discover more about the abstruse, as to make it possible for all mankind to take better and better photographs more cheaply. In following up that ambition, he made, years and years ago, long before most engineering firms were paying any attention to research of a scientific character, some remarks that deserve to make his name memorable far into the future. "Scientific research," he said, "is the yeast of business. It leavens the mass, transforming it into a system which results in the continuous production of new and valuable inventions. At the same time, like yeast, science grows as it is nourished by the industry it is transforming. Thus the association of science and industry strengthens both, and this is reflected in material prosperity and intellectual progress." The nature of the link between research and business could not be more succinctly expressed to this day. But even now it is sometimes overlooked or misunderstood. Research men, and even more so the "purer" scientists, sometimes still give the impression that they think of themselves as doing all the giving and that they believe business men often ungratefully neglect their gifts. Business men, on the other hand, especially if trained in

accountancy, tend to look askance at sums of money expended when no defined return on the money can be proved. What Dr. Mees perceived at a very early date was that the intermingling of research men's ideas with business men's ideas strengthened and enlivened both.

HOW TO START A QUARREL

The other day an acquaintance came to this office to ask us for advice as to what he should do. He explained that in a certain business matter a firm with which he had had dealings seemed quite unable to understand the real situation; and that its executives were behaving like fools. Now, we could pretend to no expert knowledge about the matter and the arguments he advanced sounded very convincing. We ventured therefore no further than to comment that the firm had been in business for a very long time and with substantial success, so that it was unlikely its executives would act foolishly. It turned out to be an unfortunate remark. He became at once incensed. If so, he declared, they must be immoral! For if they were not fools they must be aware how right he was and must therefore be deliberately acting wrongly for their own self-interest. There was nothing we could do to placate him; and our intervention, far from smoothing down a disagreement, converted a minor upset into a major quarrel.

The event did show us, however, how easy it is for a major "war" to develop out of a minor dispute. We all have some degree of self-conceit. If, therefore, we have thought out a problem with deep care we really do feel assured we have found the correct answer. It is, in consequence, an affront to our analytical ability if someone refuses to accept our answer as correct! Rather than think again, we stroke the ego; we regard ourselves as wise; we regard the man as a fool. It may even be true that he is a fool. But if he occupies such a position and conducts himself with such success that it is quite untenable to regard him as a fool it is distressingly easy to do as our acquaintance did. It is easy to argue that as he is no fool he must be aware of the correct answer even though he will not admit it; and thus to draw the conclusion that he must be refusing to accept the correct answer for some unrespectable reason, such as self-interest. The argument, in fact, runs: "As I am demonstrably right, anyone who disagrees with me must either be a fool or a villain." What terrible evils the world has suffered, what wars and persecutions have been the consequences of arguing in that way! Nation has gone to war with nation, churches and parties in the State have persecuted heretics and hunted down traitors. No mercy has been shown to those held to be villains! For persecutors and persecuted have all argued on the same lines. Each has regarded the other as an unprincipled villain. Moreover there is nearly always ground for the accusation of self-interest. With no evil intentions whatever in mind and strive though we may to be objective, each of us tends to discover more readily and weigh in the balance more heavily those facts and arguments which support our views or which will bring us benefits; and to remain somewhat deaf and blind to those which do not.

The answer has been known for centuries; yet each generation we suspect has to learn it afresh. In any discussion one's opponent must be given the benefit of the doubt. In the face of apparent evidence to the contrary he must still be assumed to be a man of truth and integrity. Additionally, humility must be acquired. As Oliver Cromwell put it in a letter, when irritated by the arrogance of the General Assembly of the Church of Scotland, "I beseech you, in the bowels of Christ, think it possible you may be mistaken."

COAL INDUSTRY

In his address at the conclusion of the annual conference of the Association of Mining, Electrical and Mechanical Engineers in June, Sir James Bowman, chairman of the National Coal Board, spoke of some of the problems confronting the coal industry and the measures being taken to meet the challenge, and said that the industry was then facing one of the most critical stages in its history. Certainly he had competition from oil in mind. Possibly he foresaw the recent awards upon pay and hours. The answer ought to be still more greatly increased efficiency and even more economic production than rules at present, before more of the industry's customers consider switching to cheaper alternative fuels. But no doubt it will be said that modernisation, yielding higher outputs per man-hour, cannot be undertaken fast enough. Moreover, there is often difficulty in closing down uneconomic pits. Strange is it not how the gloom clinging round the industry five years ago because of its inability to meet the demands for coal has now become even more inspissated through its inability to sell it? To add to that gloom there came the news, to which reference was made a week or two ago, that British Railways anticipates difficulties in moving coal. Not only is the price to go up but even to those who are ready to buy, the Board may find it impossible to supply the commodity!

The Engineer—100 Years Ago (AUGUST 31, 1860)

"FISHER'S WASHING MACHINES"

"This invention of Mr. John Fisher, of Carrington, Nottinghamshire, relates to a novel contrivance of machinery or apparatus for washing, cleansing or purifying clothes and other articles, or raw or manufactured goods, and it consists in combining with a tub or other suitable vessel, for containing the articles to be treated, a blowing apparatus for atmospheric air or any suitable gas for depuritating, bleaching, or otherwise treating the contents of the tub or vessel, whether soap by, plain, or acidulated water or other liquor be employed. He connects by means of small tubes or pipes the blowing apparatus with the tub or vessel (the blowing machine may be either a pair of double-action bellows, or any other apparatus of simple construction, capable of discharging atmospheric air or gas under the requisite pressure into the tub or vessel). The pipes may enter the bottom or sides of such vessel, or both.

"For household or laundry purposes, this apparatus is set to work or put in action in the following manner: The tub or vessel is partially filled with hot water, and the soap or cleansing mixture put into it, and the clothes or articles to be cleaned are then placed within the vessel, and the cover is put on, whereupon the blowing apparatus being set in motion by working the lever or handle, the air is forced through the liquor or liquid contents, and through and amongst the articles contained therein. This operation is continued until the required amount of cleansing or 'washing' has been effected, when the articles may be removed from the tub or vessel. For washing raw materials or manufacturers' goods, the apparatus should be made of a suitably large size, and may be worked by steam or other power instead of by hand. For washing or for purifying the various articles for which such apparatus may be employed, the blowing apparatus may either inhale atmospheric air or any of the well-known gases employed for purifying, bleaching, or discolouring goods or articles submitted to their action.

"It is well known that linen and other articles of clothing, when worn or exposed to the impurities of the atmosphere, become soiled through the deposit upon them of sooty and other extraneous particles, which, by the friction of wear, get rubbed into them, and hence require cleaning. It is claimed as the chief distinguishing feature in this invention, that the process employed for getting rid of such impurities is the reverse of that by which such articles have become soiled as above described, viz., by the agency of currents of air, which, being forced through the ley in which the clothes are immersed, the particles of dirt are, as it were, thus blown out or discharged from the fabric, and entirely removed from the surface thereof by the action which ensues."

Eleventh International Astronautical Congress

Over 900 persons—engineers, scientists, medical men and lawyers—registered for this year's International Astronautical Congress, which was held in Stockholm on August 14 to 20. The meeting was organised by Svenska Interplanetariska Sallskapet (the Swedish Interplanetary Society), and most of the proceedings took place at Kungl. Tekniska Högskolan, the Royal Institute of Technology. An attempt had been made to restrict the number of papers presented, but was later abandoned; as the period allocated for lecture sessions was less than in former years, it was found necessary to run four or five sessions in parallel. In addition to the main sessions, there were symposia or colloquia on Space Medicine, Small Sounding Rockets, Astrodynamics, and Space Law. Only the more important engineering contributions are dealt with below.

THE Eleventh International Astronautical Congress was opened at the China Theatre, Berzelii Park, by Professor Bertil Lindblad (President of the Royal Academy of Science), addresses of greeting to the participants being given by Mr. Ake Hjertstrand (Chairman of the Organising Committee), Academician Leonid I. Sedov (President of the International Astronautical Federation, and Chairman of the Commission on Interplanetary Travel of the U.S.S.R. Academy of Sciences), Dr. Richard W. Porter (Vice-President of C.O.S.P.A.R.), and Sir Harrie S. W. Massey (University College, London).

N.A.S.A. Space Vehicles

The first lecture in the main sessions was given by Dr. Wernher von Braun, Director of N.A.S.A.'s George C. Marshall Space Flight Centre, Huntsville, Alabama, who surveyed the United States Space Carrier Vehicle Programme. In the less than three years since the first artificial satellite payloads were launched, he said, the science of astronautics had advanced at a rate that sometimes surprised even the most dedicated space enthusiast. In the U.S., every possible advantage had been taken of their two first-generation carriers, the Redstone-based "Juno I" ("Jupiter C") and the "Vanguard," and within a relatively short time these vehicles orbited six "Explorer" and "Vanguard" satellites, four of which were still in orbit. No longer in service, these first-generation carriers were in many respects minimum vehicles, with orbital net payload lifting capabilities ranging from 20 to 50 lb.

The second-generation carriers include the "Jupiter" and "Thor" I.R.B.M.-based systems, now being used extensively. The "Thor Able" carriers were the first to be launched, and were used for the "Pioneer 1" Moon probe and the "Explorer 6" and "Tiros 1" satellites; the greatest achievement of this vehicle was the injection of "Pioneer 5" into an interplanetary trajectory. "Thor Agena A" has proved very successful and up to July 1960 had placed seven "Discoverer" satellites in orbit (two others have since been launched successfully). "Thor Epsilons" have a two-out-of-two record in orbiting Transit 1B and 2A navigation satellites. As for the "Jupiter"-based vehicles, "Juno 2's" launched the "Pioneer 3" space probe, "Pioneer 4" artificial planetoid, and "Explorer 7" artificial satellite which is still providing data for analysis.

In preparation for the third-generation carriers, an interim phase is now in progress, involving the development and testing of "Atlas"-based vehicles. In the SCORE experiment, "Atlas" proved capable of lifting itself into orbit with a small communications payload of well over 100 lb. "Atlas Mercury," also with no active upper stages, is being readied for "Mercury" manned satellite assignments, and "Atlas Able" has been tested in anticipation of lunar firings. On May 24, "Atlas Agena A" successfully orbited the "Midas II" surveillance satellite.

Four third-generation carriers are now under advanced development by N.A.S.A., but only one has been test fired. This is the all-solid-propellant "Scout", designed for use on missions where small payloads are required. Payload pace in this vehicle has been offered to other countries (including Britain) which might wish to undertake space research. "Scout" is designed to undertake both vertical space probing (e.g., 100 lb to 4000 miles) and orbital missions (e.g., 150 lb in a 96-min., 300-mile orbit). Dr. von Braun referred to it as the "poor man's satellite launcher."

The third-generation carriers embody staging optimization based on previous experience. The "Thor Agena B" is much like the "Thor Agena A," except that its second stage ("Agena B") has twice the propellant tank capacity of "Agena A" and its engine can be shut off and restarted in space. It can lift over 1000 lb into a 300-mile orbit. This same second stage is used in the "Atlas Agena B," which can boost a 5800 lb satellite into a 300-mile orbit or impact 700 lb on to the Moon.

The fourth third-generation vehicle is the "Atlas Centaur," scheduled to carry heavy payloads into orbits around Earth, on to the Moon, or out to the planets. In it, the standard "Atlas" cone frustum is replaced with a 120in non-tapering tank, to mate with the "Centaur's" thin gauge stainless steel structure of identical base diameter. Centaur is powered by twin liquid-oxygen, liquid-hydrogen engines which can be switched on and off several times in space in accordance with programmed instructions from the guidance system. It is designed to carry 8500 lb into a 300-mile orbit, to impact 2500 lb (or soft land about 700 lb) on to the Moon, or place over 1000 lb into a Mars or Venus trajectory.

The three fundamental principles upon which the carrier programmes rest are:

1. Creation of a fleet of standard vehicles with a minimum number of different designs and configurations.

2. The attainment of a high degree of reliability through repetitive use of these basic vehicles.

3. To avoid early obsolescence, insuring that each new vehicle developed incorporates the most advanced technical approaches and growth potential consistent with the required reliability.

This highly practical philosophy has been adhered to in the design of even more advanced carriers—the coming fourth generation, based on "Saturn", now under development at Huntsville. Except for "Vanguard" and "Scout," this is the first true space carrier not based directly on ballistic missile first stages.

Proposals for a large clustered-engine first stage were first studied in Spring 1957, and in late Summer 1958 design and development of "Saturn" were authorised. The original concept envisaged the clustering of four Rocketdyne E1 units of 360,000 lb thrust each (the largest single engines under development at that time), but this has now been modified to the use of eight H1 engines (188,000 lb thrust each)—a more compact version of the highly reliable and proven unit which has powered the "Jupiter" and "Thor" I.R.B.M's. It was also decided to use a cluster of "Jupiter" and "Redstone" diameter tanks, thus taking advantage of the tools and experience already accumulated.

The "Saturn" first stage has been built and tested, and measures 82ft tall and 260in diameter; its eight H1 engines burn RP-1 (kerosene) fuel and liquid oxygen and develop a total thrust of over 1,500,000 lb. Several long static burning tests approaching full thrust and full burning duration (over 2 minutes) have been successfully run, and no difficulty has been experienced in operating the eight engines simultaneously. The vehicle's all-inertial guidance will enable it to perform perfectly should one of the engines fail in flight.

Four of the eight engines are mounted in an inboard position on an eight-legged thrust frame at the aft end of the stage and are canted at an angle of 3 deg. to the longitudinal axis of the stage. The other four engines are in the outboard position, canted at an angle of 6 deg. and mounted on gimbals permitting them to turn through about 10 deg. for roll and attitude control during flight. The thrust frame is attached to the aft end of all nine propellant tanks (eight outer tanks 70in diameter and a central 105in diameter tank). Four of the outer tanks contain kerosene, the others liquid oxygen; as usual, precautions are taken to prevent sloshing. The thrust to the upper stages is carried by the liquid oxygen tanks, which are interconnected and attached to a circular spider beam at the upper end. The kerosene tanks are interconnected amongst themselves but cannot be rigidly connected to the LOX tanks as these suffer a thermal contraction of 2½in when filled.

The first configuration (C1) of the "Saturn" vehicle system is now being built and is expected to become operational in 1964. It will be about 185ft high and weigh about 1,160,000 lb at take-off, 1,000,000 lb of this being propellants. High-energy propellants will be used in all upper stages. The second stage, now under development by Douglas Aircraft Co., will be 220in diameter with four Pratt and Whitney liquid hydrogen/liquid oxygen engines of 17,500 lb thrust each. The third stage, to be built by the Convair Division of General Dynamics Corporation, is a modified "Centaur" vehicle with two second-stage Pratt and Whitney engines. It will be 120in diameter. The three-stage C1 "Saturn" will be capable of lifting 20,000 lb into a low orbit, 6000 lb to escape velocity, or placing 1000-2000 lb on the Moon (soft landing).

Present plans also envisage a C2 configura-

tion, based on the " building block " philosophy. The C1 second and third stages become the third and fourth stages respectively of the new configuration, and a new second stage is inserted. This would be propelled by four liquid hydrogen/lox engines, each of 200,000 lb thrust. The C2 vehicle would be about 230ft high and capable of placing 45,000 lb in a low orbit. With this vehicle it will become possible to undertake orbital refuelling and other orbital operations, and preliminary consideration is being given to the design of an orbital tanker, orbital cargo carrier, minimum manned space station, manned return capsule and circum-lunar flight capsule, each suitable for use as the top stage of a C2 " Saturn."

Feasibility studies for fifth generation vehicles are also in progress. These might be powered by clusters of the 1,500,000 lb thrust Rocketdyne F1 engine, which has already been statically fired at over 1,000,000 lb thrust.

Other Vehicles

Other papers dealing with vehicles included a discussion of systems engineering for the N.A.S.A. " Scout," by J. R. Clark of Chance Vought Aircraft, and a study of a procedure for determining the optimum size of orbital carrier vehicles (by H. H. Koelle, of N.A.S.A.).

Of particular interest was a composite paper by M. L. Williams, G. Gerard and G. A. Hoffman entitled " Selected Areas of Structural Research in Rocket Vehicles." Booster vehicles are at present the focus of much structures and materials research effort, and progress in three fields was reviewed.

In a solid-propellant rocket motor, the propellant is basically an incompressible viscoelastic solid subjected to both short-time and long-time loads in a temperature environment varying 100 deg. Fah. on either side of room temperature. In smaller-sized rockets a build-and-test development philosophy could be employed, but now that diameters are measured in feet the more sophisticated viscoelastic analysis outlined in this paper must be used.

The second area of research concerned shell structures constructed from homogeneous materials. In the original lifting vehicles, the structures were generally designed by compressive and shear buckling considerations, but with the transition to ballistic and space vehicles, tension structures have become more important and the analysis showed the importance of minimising stress concentrations if the high strength/weight potential of materials were to be realised. It was also shown that there was a significant improvement in efficiency on using pressure-stabilised cylinders instead of unpressurised, unstiffened or frame-stiffened shells.

The third area concerned future possibilities in the use of inhomogeneous materials for pressure vessels—filamentary materials bonded in a suitable matrix. Both glass fibres and metal whiskers are considered. It is thought that eventually it will be possible to reduce the weight of pressure vessels to one-fifth to one-eighth of present values, and that even to-day these materials are competitive and show some advantages over metal vessels.

Space Probes

Some of the many American space probes were also discussed at the Congress. George E. Mueller, of Space Technology Laboratories, gave a fairly detailed description of " Pioneer V," launched March 11, 1960 into a heliocentric orbit with perihelion approaching the orbit of Venus and due to return to the vicinity of the Earth late in 1965 (14,000,000 miles out on November 14 of that year). A second approach will occur again on April 1, 1966, and the pattern will then roughly repeat every five to eight years. " Pioneer V " was the latest of a related series of probes, notably " Explorer VI," which had served to test its components, and at the same time it was itself a systems test for other probes yet to come. In designing it a great many criteria had to be weighed constantly and the effect of varying one part of the payload on all other factors in the system considered. There was a constant pressure to increase the mass of each component, to obtain greater reliability, greater power, or a broader spectrum of measurements, but each pound added reduced the velocity at burn-out and thus the distance travelled towards the Sun. Individual optimisation studies were performed for all subsystems ; thus the final power supply system consisted of 17·2 lb batteries and 10·3 lb solar cell paddles, and was optimal in that subtraction of weight from either resulted in an even greater increase in the other. Both " Explorer VI " and " Pioneer V " incorporate a digital telemetry system (Telebit) which improves the efficiency of the communication system and eliminates a large number of manual operations on the ground. With the analogue system used on " Pioneer I," several months were required to analyse the data received from the two-day flight ; this system is obviously unsuitable for lengthy flights.

The data already obtained from " Pioneer V " not only includes much information on the physics of space ; the long-range tracking has already been sufficient for the mass of the Sun to be redetermined and the Astronomical Unit to be estimated to an accuracy of at least 0·03 per cent, thus contributing to the accuracy of future space navigation.

" Discoverer "

H. Evans of the U.S.A.F. Ballistic Missile Division gave a detailed account of the " Discoverer " satellite programme : its history and objectives, the space vehicle and its subsystems, the type of experiments performed, reliability considerations, and manufacturing and test facilities. This was highly topical, as " Discoverer XIII " was recovered just before the Congress and " Discoverer XIV " successfully snatched by aircraft as it returned from orbit midway through the Congress week. These were the first two man-made objects known to have successfully survived re-entry into the Earth's atmosphere from orbit. These feats were soon to be surpassed by the recovery of the 4½-ton Russian spaceship launched the day after " Discoverer XIV."

One of the " Discoverer " satellites was exhibited at Stockholm ; it consisted of a re-entry system (heat shield and afterbody) and a recoverable system (capsule with location and recovery aids). The re-entry heating problems are different from those of ballistic missile nose cones, because there is a relatively gradual descent back into the atmosphere and thus exposure to intense heat for longer times—minutes instead of seconds.

A retro-rocket aimed backwards and 60 deg. down from the horizontal plane pushes the nose section out of orbit ; after burn-out the vehicle is travelling at slightly less than orbital speed and following a path inclined less than 5 deg. from horizontal. Drag and heating effects become severe at about 350,000ft and the surface temperature of the protective heat shield rises to about 4000 deg. Fah. (the inside of the shield is gold plated to retard the passage of radiant heat).

During this heating period the surrounding air becomes ionised into a plasma which blocks radio signals, but re-entry data is recorded on tape for transmission when the period ends. This takes place at about 135,000ft (after two minutes). During this period deceleration has taken place at up to 10–15 *g* and the vehicle has travelled from over Alaska to the Hawaiian islands. The bowl-shaped heat shield (27in long, 33in diameter) has dissipated heat by ablating—melting and vaporising. The trajectory has become more nearly vertical. At a specified altitude, the cone-shaped afterbody comes off, and a parachute pulls the capsule free of the heat shield.

The capsule is constructed of aluminium alloy, with a wall thickness of about ¼in, and can contain either a small monkey or a colony of mice, in specially designed life cells with provision for automatic feeding. However, the long run of failures has so far prevented this : the latest " Discoverers " contained instruments designed to give information about the reasons for the earlier failures. The decision was taken long ago that animals would only be used when two or three instrumented satellites had been recovered successfully. Now that this has been done, it is likely that a biological " Discoverer " will be launched within a few weeks—especially as the Russians have succeeded in recovering their spaceship, apparently at the first attempt.

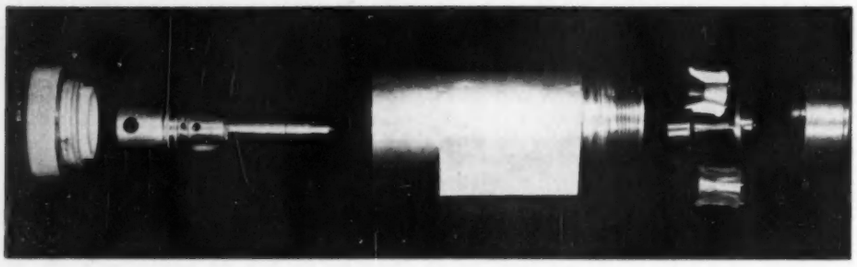
Propulsion

Several papers were concerned with propulsion, mostly with advanced techniques. S. K. Hoffman of Rocketdyne surveyed present and future propulsion systems. While the highest potential performance in chemical rockets will be provided by cryogenic liquid-propellant engines, there is still a place for storable liquid-propellant engines of high performance, which have a greater versatility as regards thrust control and restart capabilities. There are serious proposals for solid-propelled booster rockets of over 1,000,000 lb thrust for space applications, e.g., to enable the " Saturn " to lift even greater loads than at present conceived. On-site loading of these large solid motors might be employed ; the Rocketdyne " Quick-mix " process was now in the development stage. In this, the propellants are blended in a truck-mounted mixer in a few seconds with very little heat build-up, only a small amount of propellant being in the mixer at any moment.

The nuclear engine is in its development infancy. The propulsion unit will be of the open-cycle heat-exchanger type, but it may eventually be developed to operate closed cycle also, to generate power for vehicle use and for ion engines, which are attracting great interest in the United States at the moment.

Dr. Ernst Stuhlinger (N.A.S.A.) reviewed progress in electrical (ion) propulsion systems, listing nine types : nuclear-heated, resistance-heated, arc-heated (or electrothermal), solar-heated, electrostatic, electrodynamic (or magneto-fluid mechanic), solar sail, partial photon and ideal photon. Three have been rather widely studied : (i) arc-jet engine, in which thermally-heated gas is ejected through a supersonic nozzle ; (ii) ion rocket, or electrostatic, engine, in which positively-charged ions are accelerated rearward in an electrostatic field ; and (iii) M.H.D. (magneto-hydrodynamic) plasma engine, in which a plasma of ions and electrons (aggregate charge neutral) is accelerated by means of a

magnetic field. Thrust devices of these kind will produce thrusts of the order of 1 to 500 grammes and are suitable for operation out in space for near-Earth journeys where time is not important, e.g., moving large masses of equipment from one orbit to another. The electrical engine produces a low thrust for days on end, whereas the chemical rocket gives a high thrust for a few minutes at most. The electrical engine will also have advantages over the chemical for journeys to the outermost planets of the solar system.



Exploded view of Avco engine

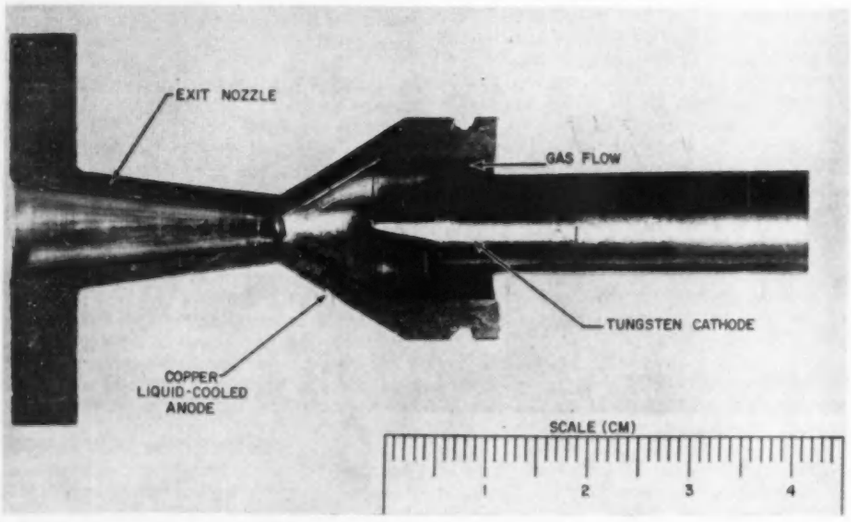
These thrust devices are accelerator units only and require two additional elements : a supply of working fluid (liquid hydrogen for the arc-jet or M.H.D. engines ; caesium for the ion rocket) and an electric power source. The weight of the three components can be determined only after the mission has been decided : the accelerator will only weigh a few pounds, the power supply a matter of tons, and the mass of propellant will depend on the duration of the journey.

Considerable progress had been made in building and testing these devices and at the present rate of development a thermal arc rocket engine would be in service in about two to three years, ion engines giving specific impulses of 3000–20,000 sec. in about four to five years, and an M.H.D. accelerator in three to ten years. It would be possible to build an electrically-propelled Mars ship to-day, but an improvement in performance was still possible. The specific power of present engines (20kW upwards) was about 0·1kW/kg. Large vacuum chambers had been built for testing these experimental engines, but for carrying out prolonged tests on later designs it would be necessary to emplace them out in space. The chief problem at the moment was that of ensuring beam neutralisation.

R. R. John, J. F. Connors and A. Mironer of Avco Corporation described a working 30kW arc jet rocket engine consuming about 85 lb hydrogen per twenty-four hour day operation. This is the simplest and furthest developed of the present electric propulsion devices. Hydrogen is injected into the arc chamber, heated by Joule heating as it passes through the discharge, and expanded through a conventional rocket nozzle. The engine has been run successfully on both hydrogen and helium for periods of about fifty hours. It weighs only 3·5 lb and has a tungsten composite cathode and a liquid-cooled copper anode. The overall efficiency (electric to kinetic) varies from 35 to 75 per cent according to the conditions.

W. H. Bostick and H. Byfield (Stevens Institute of Technology) reported on their work with a high efficiency plasma motor. This generates a plasma from the end of a small-diameter metal wire and is capable of converting 32 per cent of the energy in a stored capacitor into kinetic energy of the plasma. The plasma speed has been measured by three methods, including use of a "calendulum," a combination ballistic pendulum and calorimeter.

Other papers on propulsion included "Electrostatic Propulsion Design Principles and Problems," by J. M. Sellen, Jnr., H. Shelton and D. B. Langmuir (Thompson Ramo Woolridge Inc.), "Heliodyne : A Solar-Powered Interplanetary Vehicle," by E. T. Benedikt, R. W. Halliburton and C. C. Kelber (Northrop Corporation), "A Nuclear-Thermionic-Ionic Propulsion System," by J. E. Cobb *et al.* (Lockheed Aircraft Corporation), "Ion Engine Test Laboratory Planning," by R. O. Dietz (U.S.A.F.), "Experiments and Theory for Continuous (Steady) Acceleration of Low Density Plasmas," by R. V. Hess (N.A.S.A.) ; "Physico-Chemical Aspects of Solid Propellant Combustion," by Professor M. Summerfield (Princeton University), "Internal Ballistics of Photon Rockets," by W. Peschka (Technische Hochschule, Vienna), and "Some Notes on High-Speed Medium Propulsion," by J. B. Fenn (AeroChem Research Laboratories Inc.). In his paper "Applications of Propulsive Fluid Accumulator Systems to Orbital, Lunar and Interplanetary Missions," S. T. Demetriades (Northrop Corporation) elaborated the suggestion he advanced last year (*J. Brit. Interplan. Soc.*, 1959–60, 17, 114) for a PROFAC system to collect and store gases in the upper atmosphere of a planet for subsequent use as a working fluid in the propulsion of a space vehicle.



Model 50 arc plasma generator configuration

Power Supplies

The practical application of space nuclear power in the 1960's was discussed by J. R. Wetch and H. M. Dieckamp of Atomics International, in conjunction with Lt.-Col. G. M. Anderson (U.S.A.F. and U.S. Atomic Energy Commission). Three nuclear reactor space electric power units are under development by the U.S.A.E.C. Office for Aircraft Reactors for the U.S.A.F. and N.A.S.A.; between them they cover the power range 300W to 35kW.

SNAP 10 covers the sub-kilowatt region ; it utilises thermoelectric power conversion and has no moving parts. Its extreme simplicity ensures high reliability, long endurance (one to three years), and the possibility of remote orbital start-up. It employs uranium-zirconium hydride fuel plates from which heat is conducted through a beryllium reflector and doped lead telluride thermoelectric converter to radiating fins. Its unshielded weight is about 355 lb and it will become available in 1963.

One year later SNAP 2 should become available. This has a somewhat similar reactor, but its heat is removed by liquid sodium-potassium alloy to a mercury boiler-superheater. The mercury vapour is expanded through a turbine coupled to an alternator, then condensed in a radiator-condenser forming part of the outer skin of the space craft. The Na-K primary coolant is circulated by a rotating permanent magnet pump, and the mercury condensate returned to the boiler by a feed pump. All the rotating components are mounted on a common shaft, so that this is the only moving part ; it is supported on mercury dynamic bearings. SNAP 2 will have an unshielded weight of 600 lb and a power output of 3kW.

SNAP 8 is a larger version of SNAP 2 and will produce 35kW with one power conversion unit (1500 lb) and 70kW with two coupled to the same reactor. This should be available in 1965.

SNAP units are designed to burn up and disperse on re-entry from high orbits. Burn-up should occur above 200,000ft. Future tests may include actual re-entry tests of non-activated specimens to confirm this ; ballistic missile trajectories would be employed. It is estimated that if one SNAP 2 reactor re-entered every year after only a short decay time it would take over sixty years to build up the Sr^{90} background to 1 per cent of the background level that would then exist if no further bomb testing takes place.

Meteorological and Communication Satellites

S. Sternberg (Radio Corporation of America) reported on the post-launch per-

formance of the "Tiros 1" satellite, the first of the experimental television-equipped meteorological satellites to be launched in the N.A.S.A. programme. "Tiros 1" contains one wide-angle and one narrow-angle (high resolution) TV camera for photographing the Earth's cloud cover from an altitude of 400 miles.

The performance in orbit is still being evaluated but it can be said that the thermal design has proved quite successful, as has camera coverage and resolution. The power supply has proved more than ample and radio communications have been reliable. The function-controlling clock of one camera system went out of operation for several weeks but later returned to satisfactory working. The attitude of the satellite's spin axis changed at a greater rate than expected.

"Tiros 1" has proved extremely valuable as a meteorological research tool. Large area weather systems have been photographed and identified; both known and apparently new cloud and weather phenomena have been observed. Satellite meteorology will become an established branch of weather research and forecasting.

The potential usefulness of an artificial satellite in meteorology was examined in detail by R. P. Havilland of the U.S. General Electric Company. Mr. Havilland also provided the ideas behind one of the many technical films screened during the week. This was Walt Disney's "Eyes in Outer Space," which envisages a weather control bureau which can not only observe the weather by means of satellite stations fitted with zoom cameras to be focused at the controller's will, but which will also be able to influence the future course of the weather. In this film, a hurricane sweeping in towards the East coast of America is diverted by seeding two inland low pressure areas with silver iodide released from rockets, thus accentuating a high pressure region between them. In this piece of science fiction (thought to be technically realisable), the controller giving his orders reminds one of the first chapter of Genesis, but he is at least shown as running into the danger of causing floods in the low pressure areas and having to avert these also.

Another important commercial use of satellites is for communication. The "Echo" satellite was launched just before the Congress and many delegates had their first sight of this during the Congress excursion to the Drottningholm theatre on the Wednesday evening. For practical use, the "twenty-four hour" equatorial orbit has generally been favoured in the past; in this orbit (22,300 miles altitude) the satellite appears to remain stationary above a point on the Earth, but it is necessary to correct for drift due to perturbing forces. H. K. Karrenberg and R. E. Roberson (Systems Corporation of America) read a paper on the guidance and control of this type of satellite.

Another type of orbit was recommended by W. F. Hilton and S. R. Dauncey (Astronautics Division, Advanced Projects Group, Hawker Siddeley Aviation, Ltd.) in their paper "Communications Satellite Orbits"—the only British contribution to the main sessions. Published data for the "Blue Streak"/"Black Knight" combination (the only British vehicle likely to be available for some years, and even that is not yet certain) indicated that Britain would not be able to launch a repeater satellite into the twenty-four-hour orbit. Passive balloon satellites of the "Echo" type could be launched into the orbit using this vehicle, but a great number of these balloons would be needed for practical purposes and this would require a prohibitive number of rockets.

It would be possible for it to launch repeater satellites into elliptic orbits, however, and it was found that these could give coverage superior in a number of respects to that of circles, including the twenty-four-hour orbit. The ellipses would have apogee heights of the order of 8000 to 25,000 miles, perigees of a few hundred miles. If the orbit is carefully chosen, the satellite communication link then becomes available at times when transocean cables are experiencing their peak use, so that it will supplement rather than replace them. A network of these orbits, either near-equatorial or at 63 deg. inclination, could give world-wide coverage.

The other British contributions (both from the R.A.F. Institute of Aviation Medicine) were in the Space Medicine Symposium, when Flt-Lt. J. C. Guignard dealt with "Human Frequency Response to Vibration," and Flt.-Lt. J. Billingham with "Control of Microclimate Temperature in Very Hot Environments." Over sixty persons from Britain attended the Congress, however, and were disappointed to find that there were no other papers from this country on engineering aspects of astronautics. This is only to be expected, however, in view of the Government's continued indecision as to whether Britain should undertake space research.

Five Russian papers were read in the main sessions. These were concerned solely with the results obtained from space probes and satellites, and as usual nothing was said about the launching vehicles.

I.A.F. Council

Three plenary sessions of delegates of the member societies of the International Astronautical Federation were held. Professor L. I. Sedov (Russia) was re-elected President of the Federation for a further year and the following were elected Vice-Presidents for the coming year: Professor J. Péres (France), Professor R. Pesek (Czechoslovakia), Dr. H. Seifert (U.S.A.), Dr. L. R. Shepherd (U.K.), and Obering. F. Staats (German Federal Republic). Next year's congress will be held in New York in October, 1961, and will be timed to precede immediately the American Rocket Society's annual convention. It is hoped that the Congress will be held in the United Nations Headquarters, and an attendance of several thousand is expected.

The I.A.F. Council formally approved the constitution of the new Academy of Astronautics, an international body organised along the lines of the Royal Society and already endowed with 75,000 dollars by the Guggenheim Foundation. A first list of forty-five Academicians has already been issued; this does not include any Russians, who have decided not to participate in the Academy. Only four British scientists and engineers have agreed to join the Academy: Mr. A. V. Cleaver (Rolls-Royce), Dr. J. G. Davies (University of Manchester), Professor E. C. B. Lovell (University of Manchester), and Dr. L. R. Shepherd (U.K.A.E.A.).

100-Ton Travelling Monotower Shipyard Crane

A travelling monotower crane designed to handle loads of up to 100 tons at 122ft radius has been designed and built by Butters Brothers and Co., Ltd., for Cammell Laird and Co., Ltd. This crane, stated to be the largest of its design yet built, weighs some 890 tons and its 120ft high tower has a portal opening 48ft high by 49ft wide. It is fitted with a 175ft long aluminium alloy jib, the 10-ton auxiliary hoist of which has an effective working radius of 170ft.

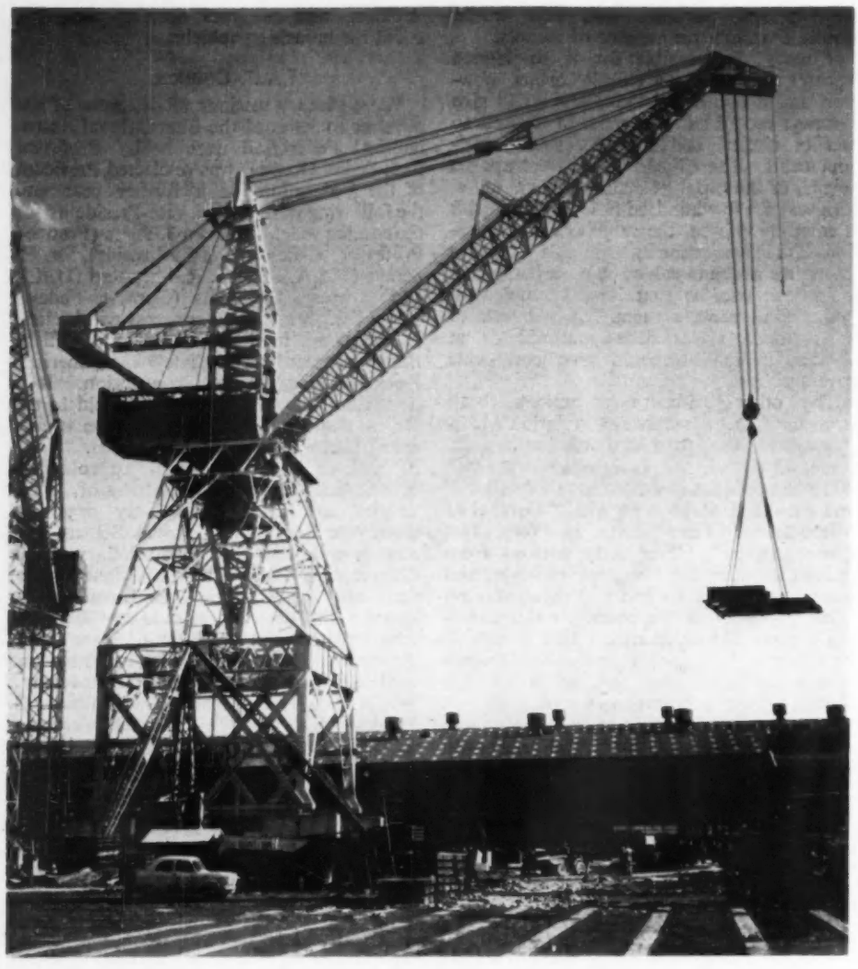
As part of an extensive modernisation plan being carried out at the Birkenhead shipyards of Cammell Laird and Co., Ltd., a number of travelling monotower cranes of 15, 50 and 100 tons capacities are being installed by Butters Brothers and Co., Ltd., of Glasgow. Two 100-ton cranes being supplied under this order are for transporting large prefabricated sections from the welding bays to the slipway and the first of these cranes, which has just been handed over after completing acceptance tests, can be seen in the illustration on the next page. This crane, of completely new design, is stated to be the largest travelling monotower crane yet built; its main features are listed in the table below and its general design is shown in the diagram on page 387.

Tower	120ft high
Jib	175ft long
Rail centres	55ft
Loads:	
Main hoist	100 tons at 122ft radius
	75 tons at 132ft radius
	60 tons at 145ft radius
	40 tons at 160ft radius
Auxiliary hoist	10 tons at 170ft radius
Speeds:	
Hoisting main	100 tons at 10ft/min
	40 tons at 25ft/min
Hoisting auxiliary	10 tons at 90ft/min
Luffing	100 tons at 28/30ft/min
Slewing	100 tons at 180ft/min
Travelling	100 tons at 40ft/min

In full working order the new crane has an overall weight of about 890 tons and is capable of lifting the maximum rated load of 100 tons at a radius of 122ft whilst standing free on its 55ft centres rail track. The base of the 120ft high travelling tower gives an effective portal opening 48ft high and 49ft wide to give a free passage to the building berths set some 50ft below rail level. The top of the revolving mast is 214ft above rail level and when the 175ft long luffing jib is at minimum radius of 52ft its uppermost point is some 300ft above rail level.

The main crane structure, with the exception of the aluminium alloy jib, is built up of rolled steel sections and plates which largely comprise welded prefabricated units riveted together on site. The machinery house behind the driver's cabin, 126ft above rail level, is 55ft long by 24ft 6in wide and 15ft high, and extending from a structure above it is the ballast box of 112 tons. A spherical roller bearing at the bottom of the mast carries the 580 tons deadweight of the revolving portion. This design of bearing is used to provide for the changes in alignment which occur due to the deflection of the structure and also to transmit the horizontal reaction at the base of the mast.

Horizontal slewing rollers fitted immediately below the machinery frame transmit the horizontal reaction from the mast to the roller path at the top of the tower. Four of these rollers are fitted at the back of the mast and four at the front, and they are mounted in pairs on compensating beams



100-ton electric travelling monotower crane handling a prefabricated section in shipyard during acceptance tests

to ensure that the load is transmitted equally through each of the rollers. To give lateral stability four other rollers are fitted, two at each side of the mast, and this whole system forms what is in effect a large radial roller bearing.

The jib, built up of riveted aluminium alloy sections and plates, consists of two main four-angle sections securely braced together by a system of diaphragms and horizontal bracings. This jib, with 175ft centres is 8ft 6in deep over the main angles and 16ft wide. It has a cantilever section at the top which carries the auxiliary lifting unit at 13ft centres. At its outer end the jib is supported by a multiple rope reeving. The bridle rope is reeved in four parts between the jib point and the bridle frame and it passes round compensating pulleys to equalise loads on the four parts of the rope. The bridle frame also carries pulleys through which the luffing rope, in eight parts, is reeved. The main hoist rope is reeved from the barrel to the mast top and thence to the jib point where it is reeved through three pulleys on the main hoist block to form the six-part reeving system. The return part of the main hoist rope is reeved between the jib point and the mast top before it passes over a " Wylie " indicator and down the mast to a levelling barrel. This arrangement imparts a levelling effect on the load path and, combined with the levelling gear, gives a level path during lifting. Reeving of this design reduces the load on the luffing gear with a consequent reduction of the power required in the luffing motor. It further serves to reduce the size of the bridle and luffing ropes used in the system.

The main hoist motion is driven by a slip-ring reversing motor with a one-hour rating of 115 b.h.p. and is shown in one of our illustrations. It is designed to lift the maximum 100-ton load on a triple pulley block at a speed of 10ft per minute. Through a change speed clutch, loads up to 40 tons can be raised at a speed of 25ft per minute. An electro-mechanical brake fitted to the motor extension shaft is capable of controlling the loaded motion and an additional spring-loaded, air-released, disc brake is included in the motion on the barrel pinion shaft. This brake is spring loaded continually in the " holding " position and is released by air through a regulator valve in the operator's cabin. Electrical counter-current lowering is also provided. The main hoist rope barrel is 10ft diameter by 11ft 8in long and is machine grooved to suit the $1\frac{7}{8}$in diameter rope of 6/37 construction. The main hook of the crane, of " Flemish Eye " design, is mounted on a taper roller bearing and, as already mentioned, is suspended from a triple pulley block for lifting the loads on six falls of rope.

The auxiliary hoist motion located within the mast frame is driven by a separate slip-ring reversing motor of 95 b.h.p. and it is designed to lift loads up to 10 tons at a speed of 90ft per minute. The auxiliary hoist barrel is 3ft 9in diameter by 5ft 6in long, machine grooved to suit the $1\frac{1}{8}$in diameter rope of 6/37 construction. An electro-mechanical brake fitted to the motor extension shaft is capable of controlling the loaded motion and counter-current lowering is incorporated. The auxiliary hook is also of the " Flemish Eye " form, suspended from a ball bearing swivel housing.

The jib luffing equipment consists of totally enclosed worm and spur gearing driven by a 95 b.h.p. reversing motor and it is fitted with a spring-loaded, air-released, disc brake and an electro-mechanical brake. Its 4ft 9in diameter 12ft long barrel is machine-grooved to take $1\frac{3}{4}$in diameter rope. The levelling barrel, to which the return part of the hoist rope is anchored, is coupled with the luffing barrel through a spur drive so that when the luffing rope is paid out, the hoisting rope is coiled in at the proper speed to give the desired horizontal path of the load. This arrangement reduces the horse-power required to luff-in the jib as the torque applied to the levelling barrel by the return part of the hoist rope tends to rotate the luffing barrel in the direction required to luff in the jib.

The slewing motion is driven at 720 r.p.m. by a reversing 55 b.h.p. motor and a 100-ton load at the maximum radius of 122ft can be slewed at up to 180ft per minute. The motor of this motion drives a single-reduction spur gear box through a flexible coupling and double output shafts from this box drive the final drive shafts of the motion through twin sets of reduction gears. The final drive shafts each carry slow-rate spur pinions which mesh with the main race gear ring bolted to the top of the travelling tower structure. This ring is some 32ft diameter and is made in twelve segments bolted together ; its inner face is machined to provide the horizontal roller path on which the horizontal slewing rollers bear.

An electro-hydraulic brake is fitted on an extension to the slewing motor shaft and when the main isolating switch of the crane is moved to its " on " position the brake is automatically released to leave the slewing motion under control of a hydraulic pedal in the driver's cabin. When the main power supply is switched off and the crane is to be left unattended the brake is automatically supplied. Each of the twin reduction gear drive boxes on the final drive shafts of the slewing motion is fitted with a slip friction clutch drive. In these cone clutches a load, applied by compression springs, is set to transmit the full torque required to slew the crane. Should this torque be exceeded by momentum of the rotating parts the clutches will slip. In this way the effect of any shock load due to sudden stoppage of the slewing motion is prevented from being transmitted back to the main drive.

The crane is mounted on four eight-wheeled bogies, one at each leg. Four of the eight centre-flanged wheels on each bogie are driven by worm and spur gearing from a 32·5 b.h.p. totally enclosed slipring motor and the four travelling motors are synchronised. These bogies incorporate a system of compensating girders which serve to take up irregularities in the track and spread the load evenly over all the wheels at each corner of the crane. Each of the driving motors has a flexible coupling on the extension shaft and two of the couplings are fitted with the large diameter brake wheel of an electro-mechanical brake. With these brakes there is a time-lag before application through the controller to prevent undue shocks to the crane structure in the event of sudden application.

The driver's cabin projecting from one corner of the machinery house is extensively glazed to give a clear unobstructed view of

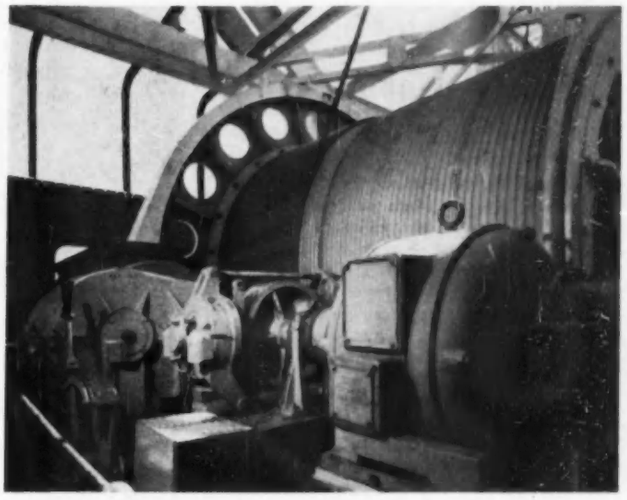
loads being handled. A separate contactor panel controls each motion of the crane and each motion is controlled by a cam-operated master drum controller mounted on a frame at the front of the driver's cabin. Control equipment for the main hoist motion consists of the necessary contactors to give plain rotor-controlled hoisting with counter-current lowering under supervisory control of relays connected across the sliprings of the motor. The panel has relays which work in conjunction with the " Wylie " safe load equipment and is suitable for use with a 24in diameter, d.c. shunt wound brake. For the auxiliary hoist motion a similar panel and brake are used.

The luffing motion control equipment consists of a negative phase sequence panel, with contactors to give plain rotor-controlled " luffing-in " and " luffing-out " by the unbalancing of the stator voltages of the motor through an inbuilt transformer. This panel is also suitable for use with a 24in diameter, c.d. shunt-wound brake.

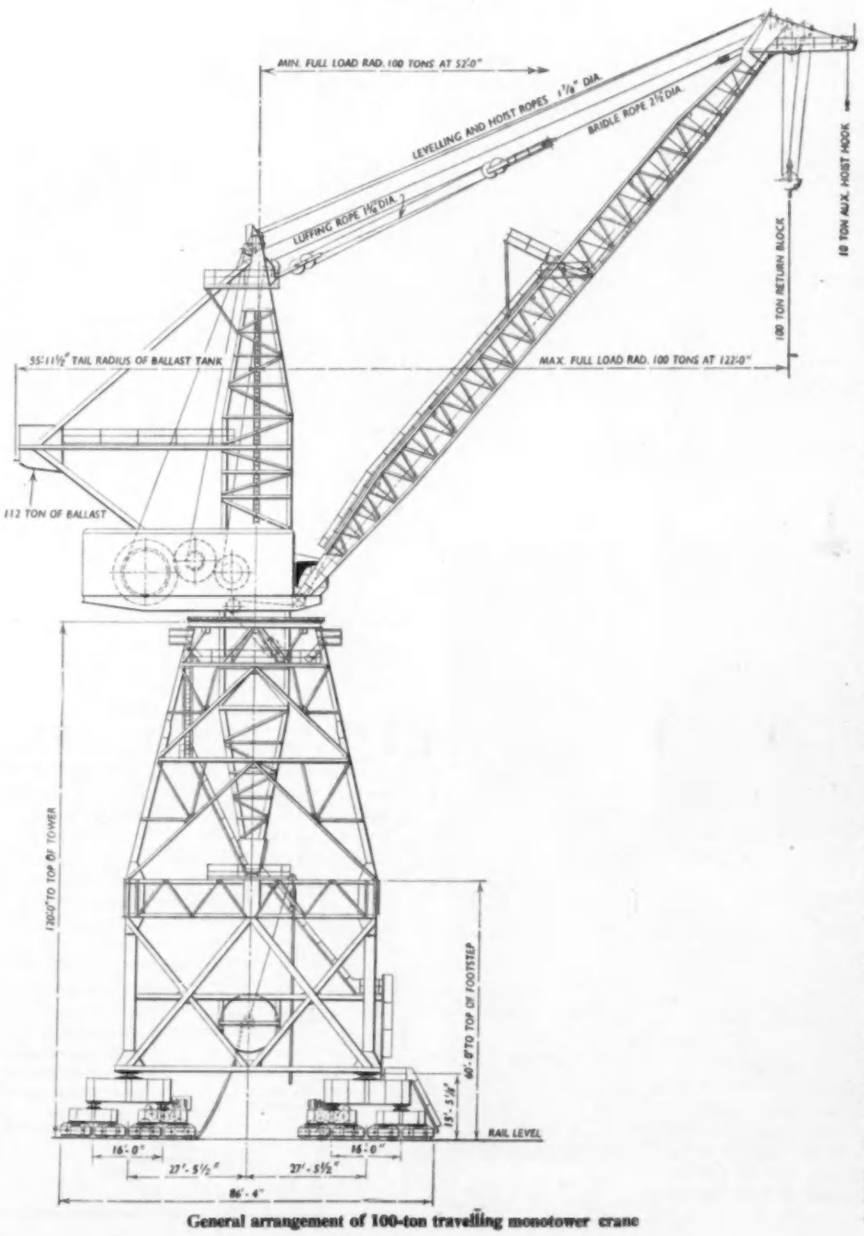
The slewing motion equipment incorporates contactors to give plain rotor control and plugging in both directions. Plugging ensures a quick accurate stop or reversal under the control of the master controller without having to use the brake. This panel is designed for use with an 18in diameter, electro-hydraulic brake. In the travelling motion control the contactors are arranged to give plain rotor control and plugging in both directions to operate all motors simultaneously. This panel is fitted with a timing relay to ensure a time delay so that the brakes do not set immediately the controller is brought to the " off " position, ensuring smooth braking.

A totally enclosed slipring collector column fitted above the bottom gudgeon-pin at the mast bottom has the necessary number of rings for the main supply, travel motors, &c. Each ring is fitted with two-controller type fingers with renewable carbon tips. On one side of the tower there is a counterweight-operated, cable reeling drum of radial design, incorporating four phosphor bronze slip-rings, which in turn are fitted with two carbon brushes, three of which are insulated for power and the fourth uninsulated for earthing purposes. The drum has a " fuzee " type counterweight barrel extension, together with wire rope pulleys and cast iron balance weights. It is capable of carrying 540ft of four-core round, flexible trailing cable.

A double-pole shunt type limit switch is fitted on the main hoist motion, so that in the event of the hook overhoisting, the circuit is broken and the current cut off for the electro-mechanical brake automatically to come into action. Two single-pole shunt limit switches are fitted on the luffing motion to prevent overluffing of the jib in both directions. These switches are operated by differential gearing driven by chain from the main hoisting and luffing barrels. This arrangement ensures that the main hoist switch cuts out when the hook reaches a predetermined distance from the jib point no matter at what radius the crane is operating. Also on the luffing motion double-pole series limit switches are fitted to operate in both directions to cut " off " the power supply to the motor if and when the shunt limits fail to operate. A single-pole shunt limit switch fitted on the auxiliary hoist motion prevents the over-hoisting of the auxiliary hoist hook. The " Wylie " automatic safe load indicator fitted on the main hoist and auxiliary hoist motion gives visual and audible warning. The main and auxiliary hoist panels are also fitted with relays which trip the main and hoist contactors so that a load beyond the capacity of the motion cannot be lifted.



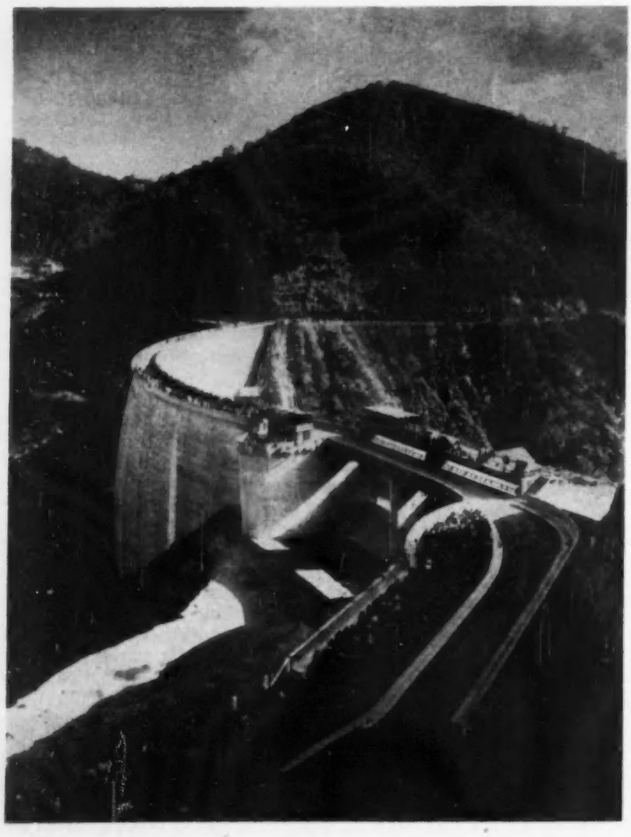
Main hoist equipment with 10ft diameter, 11ft. 8in long barrel driven by 115 b.h.p. motor



General arrangement of 100-ton travelling monotower crane

Snowy Mountains Scheme

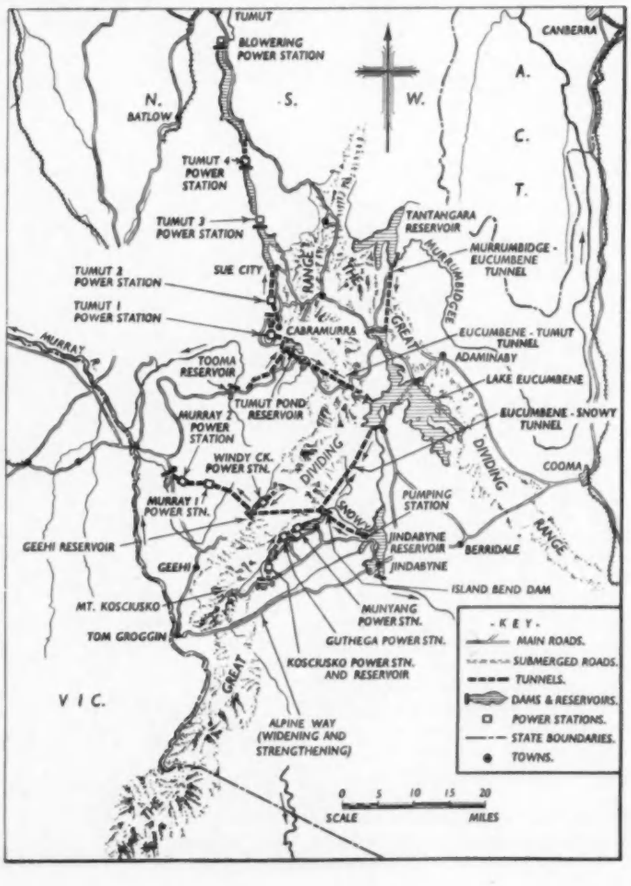
Construction of the vast complex of reservoirs, tunnels and power stations in South Eastern Australia known as the Snowy Mountains Scheme has been in progress for about a decade (see "The Engineer," June 10, 1949). Power generation and irrigation are both important aspects of the scheme, and the aim of the design has been to store the waters of the four main rivers which rise in the area of the scheme, at a high level, at the same time redistributing the flow amongst them, such that substantial additional quantities of water are diverted northwards in the Murray and Murrumbidgee (through its tributary the Tumut) to the regions where irrigation is needed. Because of this dual function, power is generated at low load factors.



directions, thus permitting redistribution of the Snowy catchment's run-off to either the Murray or Tumut, as circumstances dictate. A high level chain of power stations starting at Kosciusko reservoir will discharge into Island Bend reservoir which is situated at this redistribution point. Furthermore, run-off collected from lower levels in the Snowy catchment will accumulate in Jindabyne reservoir (capacity 250,000 acre feet, top water level 3000ft above sea level) and will be pumped into the Murray system. The Jindabyne pumping station will utilise off-peak energy, since it will draw from a large reservoir; its capacity has not yet been determined. Diversion from the "redistribution point" to the Murray catchment will follow a 9½-mile tunnel under the Great Dividing Range, to Geehi reservoir, the three reservoirs at Eucumbene, Island Bend and Geehi all at substantially the same level (i.e. in the range 3600—4000ft above sea level), thus being an indispensable part of the arrangements for redistribution of flow. From Geehi reservoir there will then be a straightforward chain of power stations along the Murray, ending in a tail-race pond below the last station.

Recently, the "high level diversion" between the Snowy and Murray was redesigned, to avoid constructional complications inherent in the earlier design, and also to make diversions of water from the Snowy more favourable. The present design is shown on the map BELOW. The key storage for the whole scheme is Lake Eucumbene in the Snowy catchment, with a gross capacity of 3,860,000 acre feet and a top water level 3822ft above sea level. Tantangara reservoir will store the headwaters of the Murrumbidgee and divert them into Lake Eucumbene. Utilisation of water flowing from Lake Eucumbene can then proceed in two ways. First, by diversion through the tunnel to Tumut Pond reservoir; that is, to the catchment of the Tumut River, where a straightforward chain of reservoirs and power stations stretched out along the Tumut controls its flow for irrigation further north as required, and generates power in the four stages shown. Tooma reservoir and tunnel are an addition to this system, conveniently available from the Murray catchment.

The second route from Eucumbene reservoir is more complicated. The Eucumbene-Snowy tunnel, which will be 15 miles long, will allow flow in both

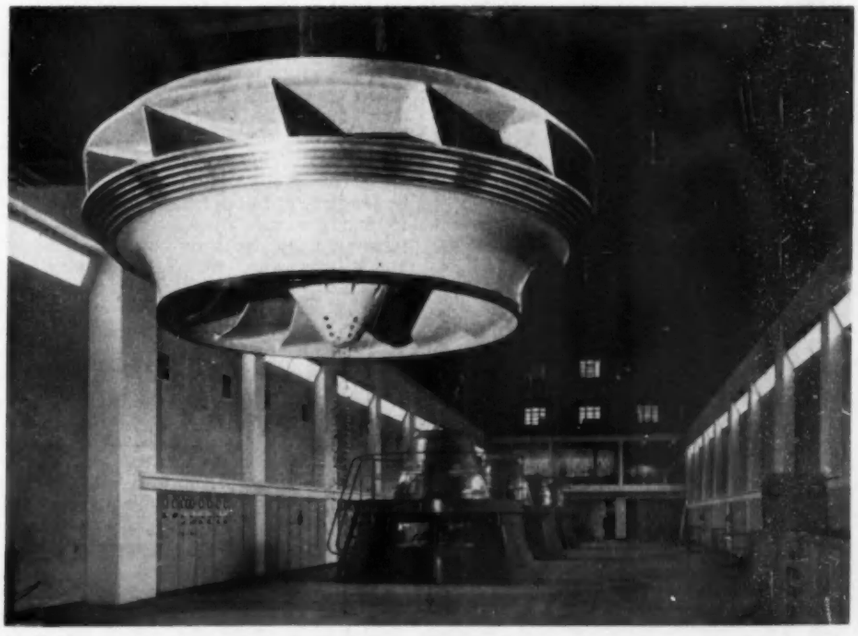


When complete, the entire scheme will provide nearly 2,000,000 acre feet of water annually in the Murray and Murrumbidgee, which will allow about 1000 square miles to be cultivated at an annual turnover of £30,000,000. The installed capacity will be about 2500MW overall, and the annual energy output 5500 × 10⁶kWh, i.e. an overall load factor of about 25 per cent. The total cost of the scheme is estimated at about £375 million. Its power stations are listed in the table herewith.

Power Stations of the Snowy Scheme

Station	Capacity MW
Snowy Catchment :	
Kosciusko	60
Guthega...	90
Munyang	60
Murray Catchment :	
Windy Creek	75
Murray 1	756
Murray 2	442
Tumut Catchment :	
Tumut 1	320
Tumut 2	280
Tumut 3	180
Tumut 4	230
Blowering	60

The first stage of the scheme to come into operation was Guthega power station shown ABOVE, which has been operating as a run of river station of 60MW capacity since 1955. The intake dam serving Guthega power station is shown at the top of page 388. These are the only works built on the Snowy River up to now. Eucumbene dam, LEFT, which is a rockfill dam with a maximum height of 381ft, was completed in 1958, and water has been accumulating in its reservoir since 1957. Tumut Pond dam, an arch structure 283ft high, shown in the second illustration on page 388, was also completed in 1958, and the tunnel supplying it with water diverted from Eucumbene reservoir was completed last year ; this tunnel has a length of 14 miles and a diameter of 23ft. The Tumut 1 underground power station, which is served by the reservoir and tunnel just named, also came into use last year ; it is illustrated RIGHT with one of the runners of its 97MW sets shown in the foreground. Tantangara dam—a concrete gravity structure—has been completed, and construction of the tunnel from Tantangara to Eucumbene reservoir is well advanced. Diversion of the Tooma into Tumut Pond reservoir is also well advanced (as recorded in our issue of June 10 last, page 988), as well as the construction of Tumut 2 power station and the various works associated with it, but the works on the Tumut downstream of Tumut 2 power station have not yet been started. Tumut 2 power station is expected to be complete in 1962, and the following year 500,000 acre feet of water will be available for diversion northwards. Construction of the first phase of the Snowy-Murray section of the scheme is due to start in the present financial year.

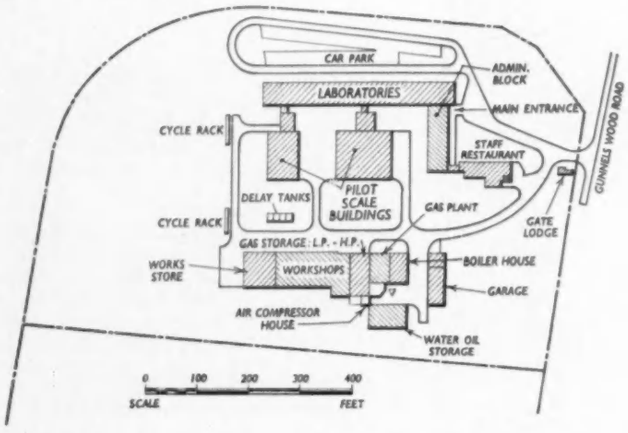


MAINLY METALLURGY

by T. Henry Turner, M.I.Mech.E. M.I.Loco.E. A.R.Ae.S. F.I.M.

The Warren Spring Laboratories

During the year since the new Department of Scientific and Industrial Research laboratories in Stevenage were formally opened in June, 1959, and named the Warren Spring Laboratories (see THE ENGINEER, August 7, 1959, pages 48–50), the investigations being carried out at that time in the former Fuel Research Station, at Greenwich, have been transferred. This newest of the D.S.I.R's research establishments now occupies a 28-acre site at the south-western corner of Stevenage New Town.



Warren Springs Laboratory site plan

"Open Days" were held there on July 21 and 22, 1960, to enable scientists to see at first hand the versatile programme of research, upon which the staff are now embarked. The visitors were invited and welcomed by the Director S. H. Clarke, C.B.E., in the hope that the facilities of these new laboratories, which are at the disposal of industry, will be widely used. For that reason he encourages inquiries and suggestions. In accordance with the Research Council's original plans for this laboratory, it is now covering several fields of immediate importance to industry, and it is planned to be available for still wider usage.

Work in these laboratories is at present divided for operational purposes into the following six divisions :

(1) Administration.
(2) Atmospheric Pollution.
(3) Chemical Engineering and Process Development.
(4) Engineering Services, Intelligence and Human Sciences.
(5) Mineral Processing.
(6) Physical and Chemical Services.

Any or all of these divisions may be of help to industry and other organisations, and these new laboratories already have in hand sponsored investigations, for which up-to-date pilot scale plant is available.

As an example, one noted work on gas absorption towers and reaction vessels of the liquid phase type, being carried out by the Chemical Engineering and Process Development Division. Similarly, the Mineral Processing Division is working on a pilot scale of up to 2½ tons an hour investigating primary crushing operations. This investigation is being aided by an intelligence and process unit, which undertakes cost studies as well as the technical and economic evaluation of research projects.

Mineral Processing

The way in which the D.S.I.R. is now paying attention to mineral processing deserves especial notice. There has always been a somewhat indetermined frontier between mining and metallurgy and sometimes this has appeared as a serious gap. In the first decade of this century Great Britain was lagging dangerously behind Germany in the special skills and know-how needed for the treatment of many of the rather unusual ores and residues of, for example, tin, zinc, and nickel. At that time there were a relatively few, associates of the Royal School of Mines in the main, who were available as expert consultants, with pilot scale plant of their own, like George Holloway. His clientele was world-wide, and in his little works and laboratory near the London Docks he received parcels of minerals sent by far-away prospectors, and he endeavoured to find processes by which his customers' minerals might be made into valuable ores. He it was who, when the country was desperately short of nickel for the armour plate of its 1914–18 warships, was sent to Canada as chairman of the Royal Ontario Nickel Commission.

In the aftermath of that war it seemed that the Government had learnt its lesson, because for some years after that the Imperial Institute, in South Kensington, had an Empire Mineral Resources Bureau, with a permanent staff and laboratory facilities. It organised committees which benefited from the unpaid but very willing help of industrialists and scientists dealing with the essential metals and other mineral resources.

The potential value of that Mineral Resources Bureau to the nation seemed very obvious in the early 1920s, but it was never developed to the full and with the recent passing of the Imperial Institute one can only hope that the Warren Spring Laboratory Mineral Processing Division grows rapidly. It has the opportunity of doing all and more than the men like George Holloway and those of us who served on the Imperial Institute Committees and the staff of the Mineral Resources Bureau tried to do, in their different ways. By providing a centre for advanced research in the field of mineral processing it should help prospectors in the far-off fields, the mineral mining industry, and the production metallurgists at home and abroad, to the better service of mankind.

Liquid-Liquid Extraction Techniques—The practical development of mineral processing during the past decade has in many fields been revolutionary. Particularly is this so in the successful development in recent years of the new extraction processes for the recovery of uranium, because this has raised the possibility of applying these techniques to the recovery of more common metals. This will only be possible if cheaper reagents can be found to replace those used for uranium. The Mineral Processing Division has been examining the possibility of using naphthenic acids for the extraction of metals such as copper, nickel, cobalt, zinc and manganese. Commercial naphthenic acids, which are derived from crude petroleum oils and have extensive industrial uses, have not previously been considered for the recovery of metals from aqueous solutions. Their cost is only about £130 a ton, compared with the price range of £640 to £1100 a ton for the alkyl phosphoric acids used in the recovery of uranium.

In the case of many complex and low grade ores it is only possible to extract the wanted metals by means of leaching with water or dilute acids, thus extracting a soluble metallic compound from the ore by dissolving it. It is in the treatment of these leach liquids that naphthenic acids may have a possible use. The metals which are extracted by the reagent depend on the degree of acidity or alkalinity of the aqueous solution of leach liquors : one speaks of this as the pH value. For example, it has been found that copper is extracted at pH 6, whereas nickel is extracted at pH 8. Thus by carrying out the extraction process in two stages, first at pH 6 and then at pH 8, separation of copper from nickel is achieved. Practical tests are now being carried out.

As this technique involves the treatment of one liquid by another, the leachings by the reagent, it is commonly referred to as "Liquid–Liquid" extraction. It can be used to obtain concentrated solutions of metals from very dilute solutions, by adjustment of the ratio of organic to aqueous phases, and in this way a concentration by up to ten can be obtained.

Atmospheric Pollution

In providing mankind with mechanical power, and essential metals and alloys, engineers and metallurgists have unfortunately polluted the air we breathe. The nature of the pollutions have been changing rapidly during recent years. The tarry grime

from the black smoke of burning raw coals no longer creates "Black Country," and smokeless zones and smoke-controlled areas are growing quite rapidly. Progress has been such that there are now over 700 of them in Great Britain. No longer do a host of chimneys blacken the cities of London and Westminster, where "smoake from sea coales" was already a foul nuisance in the days of Good Queen Bess. Unfortunately, sulphur dioxide pollution still increases and intensifies our corrosion problems, nuclear emissions threaten, and diesel engine fumes disgust us and make us ashamed of the careless inefficiency they indicate.

The extent and nature of atmospheric pollution is better understood to-day because of the continuous and increasingly important investigation which, years ago, was transferred from the National Physical Laboratory to the Fuel Research Station at Greenwich, and from there this year has moved into the fine modern buildings of the Warren Spring Laboratory at Stevenage. Two years ago Dr. A. Parker estimated that the main users of fuel in Great Britain produced, expressed to the nearest tenth of a million tons per annum, about 1,700,000 tons of smoke per annum; 900,000 tons of grit and dust per annum; 5,600,000 tons of sulphur dioxide per annum. The London "smog" disaster of 1952 may come to be regarded as a blessing to future generations because it opened the eyes of so many people to the need for immediate and drastic action.

Fortunately, at the time when they were needed the National Smoke Abatement Society included in its private subscribing members engineers, metallurgists, fuel technologists, chemists and others who gave practical help to the Beavor Committee on Air Pollution that was set up by the Government in 1953 and reported in 1954. The Clean Air Bill followed and, with support from both sides of the House of Commons, the Clean Air Act became law in 1956.

Almost every municipal authority in the country supports this popular movement towards clean air by reporting figures from their standardised tests to the D.S.I.R. This is where the new Warren Spring Laboratory has especial significance, because it has become the centre for this work, at which all these potentially significant figures are co-ordinated and evaluated. There the distribution of atmospheric pollution throughout the country is mapped in order that the now existing Clean Air legislation may be applied in the best possible way.

In these Stevenage laboratories Dr. S. R. Craxford is head of the Atmospheric Pollution Division, and he and his scientific assistants serve as this country's Atmospheric Pollution Intelligence Headquarters. They must warn Government and public of the nature and magnitude of the sometimes invisible but deadly atmospheric pollutions which may be indicated by the far spreading tests of this now essential investigation. They must take full account of the effects of weather and local conditions and assess the value of each ameliorative action.

It has been most heartening to see how quickly engineers and metallurgists joined in this work for clean air. Early in 1957 the Institution of Mechanical Engineers held a three-day conference, in Central Hall, Westminster, on "The Mechanical Engineer's Contribution to Clean Air." Later that year the Iron and Steel Institute held a most helpful two-day meeting, in Church House, Westminster, at which the Iron and Steel Industry considered every possible means of reducing atmospheric pollution.

In the following year the National Smoke Abatement Society became incorporated under the new name of National Society for Clean Air. Under the appropriate presidency of Sir Hugh Beavor, K.B.E., LL.D., it organised the International Clean Air Conference, which was attended by 1000 delegates from this country and by 200 visitors from countries all over the globe, for it appears that atmospheric pollution is now troubling all industrial countries.

It is to be hoped that some British engineers will be able to see how the Germans are tackling this problem, for we are invited to the meetings which are being organised by the German Engineers Committee for Preserving the Purity of the Air (Verein Deutscher Ingenieure V.D.I.—Kommission Reinhaltung der Luft) to be held in Wiesbaden from September 21–23, 1960. Judging from the businesslike programme and invitation, this should be a worthwhile and important conference.

A fortnight later, from October 4–7, the National Society for Clean Air should be holding its annual conference in Harrogate, and it has devoted the whole of the afternoon session on October 5 to "Air Pollution from Road Vehicles." The many papers which have been promised for this session show how seriously this relatively new form of atmospheric pollution is now regarded.

Process Development

Several of the Universities now have departments of Chemical Engineering and there are commercial laboratories where sponsored research is carried out. But sooner or later, as an inspired idea grows towards becoming an economic process of production, pilot plant operation is generally desirable. Lacking that, it is very difficult for industry to design full-scale processing plant with the accuracy and reliability necessary for wise and confident investment of capital in the new undertaking.

With this in mind the D.S.I.R. has now provided in the Chemical Engineering and Process Development Division of the Warren Spring Laboratories space and many technical aids for pilot plant operations. No doubt these facilities will be used for many purposes in the future. An example of how they are now being employed is of wide interest because distillation techniques are of almost universal importance, and even a very small percentage improvement in the rate of distillation could bring a major economy.

This laboratory has therefore set up, for pilot scale work, a highly instrumented distillation column which has twelve plates. With this the staff are studying:

(1) the area of contact between gas and liquid in the foam produced on the plate.

(2) the value of the mass-transfer coefficients in the foam.

(3) the time taken by the fluids passing through it.

These three factors govern the mass-transfer efficiency of a distillation plant plate, and may depend on the fluid's physical properties and the geometry of the plate. Appreciable progress has already been made and the results of this investigation may soon make it possible to predict the performance of distillation columns with more precision and so help designers to achieve greater economy.

Over long periods of operation, however, the maintenance of that high economy will depend on the prevention of corrosion, scale and other unwanted deposits. It therefore seems to be desirable that corrosion prevention specialists be trained for inclusion in this potentially very valuable pilot plant team.

Nickel

The demand for nickel rose sharply in 1959 and for the first quarter in 1960 the International Nickel Company of Canada, Ltd., which is the greatest producer of this metal in the world, was delivering at a rate greater than its production. Next year Inco's new Manitoba project will come into production, and other nickel producers are also increasing their capacities. The continuing high demand may therefore be more than satisfied by the industry's increased productive facilities and by the available nickel supplies.

Thus augurs well for the progress of the nickel industry in the decade now opening, bearing in mind the following figures for Inco's production of nickel, copper, and platinum metals during the past ten years.

Year	Nickel	Copper	Platinum Metals
1949 ..	209,300,000 lb	221,100,000 lb	—
1955 ..	—	—	445,000 oz (a new high)
1957 ..	—	280,800,000 lb (a new high)	—
1959 ..	317,000,000 lb (a new high)	—	—
Total for ten years	2,670,000,000 lb	2,450,000,000 lb	3,150,000 oz

These are some of the figures given by Dr. John F. Thompson, chairman of the Board of the International Nickel Company of Canada, Ltd., at its annual meeting in Toronto, followed for the first time by one in Winnipeg presaging the opening of a project in Manitoba. There the company has been spending about 125 million dollars on the mine, mill buildings, smelter and electrolytic refinery, and a complete township for 2000 Inco employees and their families.

The decision to provide a refinery in Manitoba with a capacity of 75,000,00 lb is notable, and involves taking power from the Kelsey power station 53 miles north of Thompson. The Manitoba Hydro-Electric Board is constructing the Kelsey power station, which is scheduled to deliver power to the new works in June, 1960, with full output early in 1961.

When the present writer visited the mines and smelter in Ontario in 1926 the world output of nickel was less than 60,000 metric tons a year; by 1943 it had reached a peak of 155,000 tons and in later years an output of over 214,000 tons has been achieved. It seems probable that the output will exceed 300,000 tons a year in 1962 with the development of new mining ventures in various parts of the world but especially in the neighbouring State of Manitoba, Canada.

Corrosion Problems in the Petroleum Industry

It will be recalled that in November, 1959, the Corrosion Group of the Society of Chemical Industry organised a very successful symposium, in conjunction with the Institute of Petroleum and the Chemical Engineering Group of the Society of Chemical Industry. It was held in London at the Federation of British Industries headquarters in Tothill Street, S.W.1 (see THE ENGINEER, December 11, 1959, pages 784-85).

The papers then read and discussed have now been published as S.C.I. Monograph No. 10, "Corrosion Problems of the Petroleum Industry," and copies may be obtained from the Publications Department, Society of Chemical Industry, 14, Belgrave Square, London, S.W.1; price to members £1 2s. 6d. and to non-members £1 10s. 0d.

LETTERS AND LITERATURE

Letter to the Editor

MEASURING THE WORKABILITY OF CONCRETE

SIR,—We are in sympathy with Dr. Plowman in his effort to develop a simple workability test suitable for site use and free from the limitations and inconveniences of existing tests. We cannot, however, accept his statement in THE ENGINEER of June 17, based upon Figs. 9 and 10 of his article, that "the compacting factor test has a lower limit of about 7½ per cent water below which the curve (per cent water against compacting factor) is ambiguous, having two values for a given water content."

Fig. 1 has been prepared from data recently obtained at the Royal Military College of Science Concrete Laboratory, covering the normal range of concrete mixes, and we find therein no evidence of the ambiguity reported by Dr. Plowman—the relationship being appreciably linear over the range investigated, below 9·5 per cent water content. Fig. 2 shows some results of a further restricted series of tests employing three differing procedures in preparation of the fully compacted reference specimens; the range of observations extends well below the lowest water content usable in practice, and it is again apparent that, for a given procedure, no ambiguity in compacting factor arises. It may be noted that the general shape of the curves at Fig. 2 may be predicted by considering the compacting factor test as a comparative bulking test.

Fig. 2 shows that, over a certain range, depending upon the method of preparation of the fully compacted reference specimens, there may be two values of water content corresponding to a given compacting factor. This is, however, of little or no practical significance, since the lower value normally occurs well below the minimum usable water content and any ambiguity may readily be resolved by visual examination of the mix.

We observe from Dr. Plowman's Fig. 6 that the slope test on mixes using aggregate to Grading No. 4 does not appear to give any readings for water percentages lower than about 8·3. In view of this evident insensitivity of the slope test, we find rather surprising Dr. Plowman's condemnation of the compacting factor test on the grounds of insensitivity to dry mixes.

We are in full agreement with Dr. Plowman that field workability tests should be simple, involving no complicated calculations. This latter condition does not rule out the compacting factor tests for field use, since the "several divisions and subtractions . . . involved in the calculation of the result," to which Dr. Plowman refers, may readily be eliminated by provision of a nomogram reducing the required calculations to one simple reading well within the capabilities of the average semi-skilled man.

It is appreciated that the compacting factor test does not, in general, give a closely correlated indication of the actual work required for full compaction of dry mixes. This is of little practical significance, however, since in extra-laboratory use the compacting factor test is, like the slump test, employed largely as a measure of constancy of mix proportions.

R. DAVIES
J. M. HAWKES
Materials and Structures Branch,
Royal Military College of Science,
Shrivenham.
August 17, 1960.

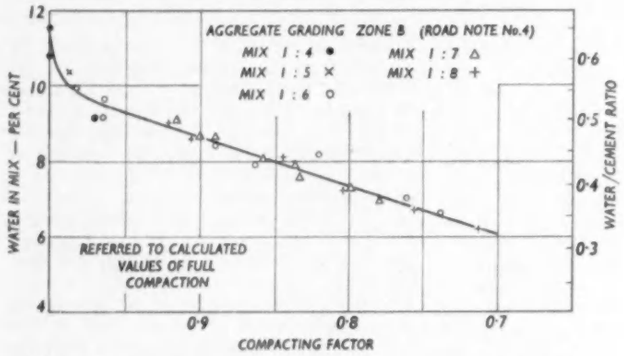


Fig. 1

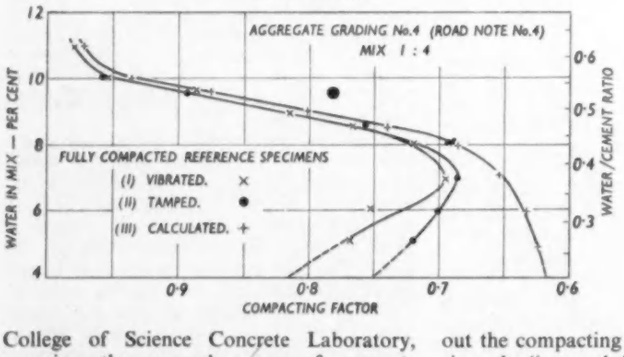


Fig. 2

Book Reviews

Rocket Propellant Handbook. By B. KIT and D. S. EVERED. The MacMillan Company, New York, 10, South Audley Street, London, W.1. Price 87s. 6d.

ROCKETS are taking an increasingly important position in world affairs and consequently their technology is becoming of interest to an ever increasing circle of engineers and scientists. Many modern college courses now devote at least some time to the basic principles and for older students there are several good textbooks covering the broad field, but so far the more detailed and specialised aspects have not been covered very extensively. The source of energy is one of the most fundamental of these aspects. In the future nuclear energy may power the large rockets we are now growing accustomed to, or possibly solar energy will be used for interplanetary voyages, but up to the present and in most applications for many years to come, chemical energy will predominate. Hence, a book discussing and tabulating the many alternative chemical propellants is a welcome extension to the literature.

The present volume does not claim to give a great deal of original data, but rather to collate the relevant results of individual researches and publications in a form both useful to the designer and easily referred to. It contains analyses of nearly 100 chemicals actually or potentially suitable for rocket propulsion. Many of the latter have not yet reached a stage where they can be applied practically, but the discussions on them will help the reader to appreciate why. In fact, each propellant has a standardised treatment giving, in greater or lesser detail, general background information, data on physical and chemical properties, methods of production and economics, problems of storage and handling, toxicity, and performance as a rocket propellant. In addition, a useful bibliography and list of references appear at the end of each section.

The chemicals included range through solids and liquids, oxidants and fuels, mono- and bi-propellants, with a final section devoted to pressurising gases. The treatment is excellent and avoids placing too much emphasis on the aspects which are or may change rapidly. For example, the price of beryllium is quoted, although it is impossibly high for normal propellant use, because it is clear that it will always remain a scarce commodity. On the other hand, the prices of boron compounds are not quoted because mass production is feasible and prices could drop steeply. Some indication of the present and future possible prices might, however, have been advantageous to the non-chemists merely as an indication of relative values. In other directions, the information provided is more definite and of great importance to the engineer. The limitations on compatibility of propellants with container materials, toxicity and handling are generally clearly described and the data on physical and chemical properties and performance are sufficient for initial assessment. It would, of course, be much more convenient if specific impulse could be quoted for a single nozzle expansion ratio rather than the many different ones actually used. As might be expected in a handbook, much of the data has been tabulated, and this has been done

both in the sections and collectively in appendices. Unfortunately, it is noted that all the figures are not in agreement. This is probably due to typographical errors as, for instance, where thermal conductivities converted from c.g.s. units to British units are an order of magnitude too great. Nevertheless, this sort of error prevents one from putting absolute reliance on the data. The authors have realised that mistakes may creep in and apologise in advance. It is a pity that such blemishes exist, but in spite of them, the book remains a useful contribution to rocket engineering.

Construction et Etalonage d'une Soufflerie à Gaz très rarefié. By F. MARCEL DEVIENNE, GEORGES M. FORESTIER, and ANDRE F. ROUSTAN. Publications Scientifiques et Techniques du Ministère de l'Air, No. 354. Paris: Magasin C.T.O.: 2, Avenue de la Porte-d'Issy, Paris (15e). Price Fr.570.

THE present issue in the series of scientific and technical publications by the French Air Ministry describes a low pressure wind tunnel in which the static pressure in the test section can vary during operation between 0·1 micron and a few microns. The pump installations comprise principally four large vacuum pumps, each with three stages. In order to calibrate the tunnel, preliminary work was carried out measuring stagnation pressures, corrections being applied using different types of static tubes of widely varying diameters. As the results showed, at a static pressure of the order of 0·67 micron, a Mach number of nearly 4 is reached along the axis.

Cybernetics and Management. By STAFFORD BEER. The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 25s.

THE desire of authors to find a "pithy" title sometimes leads the reader to experience disillusionment and disappointment. Certainly any reader who expects from the title of this book to read within it an explicit solution to his management problems by the use of cybernetic devices will know such an experience. In fact, the book presents a brief statement of the growth of cybernetics, and proceeds to a general apologia in which management problems and their solutions are only hinted at. Three-quarters of the way through it seems that the real meat is appearing with the presentation of a block diagram for a cybernetically controlled factory, but the description given is too brief to be really meaningful.

To be fair to the author it must be noted that in his preface he does not claim to be writing "a textbook or technical treatise . . . but . . . a general exposition of a new science written for anyone interested in the problem of control." Viewed from this standpoint it is more satisfactory. The basic notions of cybernetics are first discussed and some of the jargon, including such concepts as homeostats and the Black Box, is introduced. The claims of cybernetics to be regarded as a science in its own right are then propounded. Next follows the most interesting section of the book dealing with the biophysical theory of cybernetics, in which experiments with machines having the power of adaptive behaviour, and of learning and teaching, are reviewed. The final section poses some of the problems which arise when machines are required to transfer cybernetic principles into functional hardware.

The range of knowledge presented is impressive and the flow of language agreeable. However, in a book which is admittedly fairly difficult, and is intended for the earnest inquirer rather than the scientific sensationalist, certain features are regrettable. There is a too-generous use of superlatives. Also, by drawing on material from an extremely wide spectrum of knowledge, the author gives the impression that he is out to impress rather than to inform.

With these reservations the book is recommended as a useful introduction to cybernetics.

Fishing Boats of the World : 2. Edited by JAN-OLOF TRAUNG. Fishing News (Books), Ltd., Ludgate House, 110, Fleet Street, London, E.C.4. Price 147s.

THIS volume, which runs to over 800 pages, contains the major papers and discussions of the F.A.O. World Fishing Boat Congress held in Rome in 1959, together with supplementary critical and informative contributions such as the articles on purse seining and stern trawling. Fishing practice in every sea by many different kinds of craft and by a wide variety of methods is covered by some fifty selected papers and about 800 illustrations and diagrams which are divided into four major sections. Part I, under the heading "Tactics," pays particular attention to fishing methods and associated deck and operational arrangements for various designs of boats. This covers : purse seining ; drift netting ; gillnet, longline and pole and line fishing, together with trawling and control of operations. Construction is the main concern of Part II in which papers deal with scantlings, the application of new materials, and fish room engineering, and discuss propulsion problems and systems and costs. In Part III, entitled "Sea Behaviour," resistance and propulsion and hull form (touching upon coefficients and bulbous bows) are dealt with, also the sea-kindliness of trawlers and the influence of dimensions and hydrostatic qualities. The fourth part deals with productivity and provides a symposium of types of boats suitable for short, medium, and long distance fishing. Also included is a study concerning choice of size and design, and notes upon modern factory ships. This book is more than an official record of papers, for each section includes edited discussions augmented by written contributions. To serve all nations a summary of each paper is given in French and Spanish and, with the same object in view, all dimensions are given in feet and the metric system. The volume, which records the experience presented to the Congress and is of great technical value, is a welcome addition to the rather limited technical literature available to commercial fishing interests.

Books of Reference

The British Shipbuilding Compendium, 1960. Tenth edition. The Shipping World, Ltd., Effingham House, Arundel Street, Strand, London, W.C.2. Price 20s.—This buyer's guide to British shipbuilding, marine engineering, repairing, ship and shipyard equipment is divided into four sections. The range of products covered by the compendium is shown in an Index of Headings which lists the items to be found in each section. In Section A—Shipbuilding can be found the names of shipbuilders of oceangoing ships, of coastal and smaller ships and of small craft, followed by the names of ship-repairers and dry-dock owners. The builders of propulsion machinery, ranging from boilers to turbo-electric machinery, are given in Section B. Section C is the largest in the book and occupies over 300 pages which cover general items from accommodation ladders and accumulators to whistles and winches. Shipyard equipment is listed in Section D and this deals with items such as abrasives and belting and ranging to welding equipment and electrodes. Finally there is an alphabetical index to firms, of which about 1700 are involved.

Year Book of the Heating and Ventilating Industry. Technitrade Journals, Ltd., 8, Southampton Row, London, W.C.1. Price 15s.—The book opens with three contributed articles followed by a contractor's review of the year and an index of heating and ventilating literature drawn from 1958 publications. There is a selected list of pertinent British Standards and Codes of Practice, also a reproduction of by-laws relating to "The Prevention of Waste, Undue Contamination, Misuse or Contamination of Water." After the report of the Council, particulars of the national agreement as to working rules and conditions are recorded. Members are listed alphabetically and by areas and there follows the buyers' guide, also lists of trade names, manufacturers' addresses, technical and trade associations, and consulting engineers.

Classified List of Equipment and Services. The Council of British Manufacturers of Petroleum Equipment, 2, Princes Row, Buckingham Palace Road, London, S.W.1. Price 10s.—This is the 1960 edition which has been revised and enlarged to bring up to date the information in the biennial catalogue, "British Petroleum Equipment," 1959-60 edition. The separate edition includes the list of members, an index to the classified list and the classified list with the items of equipment arranged alphabetically and associated with the names of manufacturers. An additional seventy-eight members are recorded and the headings and sub-headings have been considerably extended to cover, the increased spheres of activities of the members and to expedite the location of equipment items and the manufacturers concerned.

Approved Methods for the Physical and Chemical Examination of Water. Third edition. The Institution of Water Engineers, Parliament Mansions, Abbey Orchard Street, London, S.W.1. Price 10s.—The first edition of this important work originally appeared in the form of a special issue of the *Journal of the Institution of Water Engineers* for October, 1949. It is now regarded as the standard work for the physical and chemical examination of water.

Only a limited revision of the second edition has been attempted. The chief revisions or additions in the new edition include those sections dealing with the determination of nitrate, sulphate, sodium and potassium, aluminium, copper, lead, zinc, and synthetic anionic detergents. A brief index is also included.

Books Received

Coastal Changes. By W. W. Williams. Routledge and Kegan Paul Ltd., Broadway House, 68-74, Carter Lane, London, E.C.4. Price 28s.

Effects on Nuclear Radiation on Men and Materials. By T. C. Helvey. Chapman and Hall, Ltd., 37, Essex Street, London, W.C.2. Price 15s.

Numerical Methods for High-Speed Computers. By G. N. Lance. Iliffe and Sons, Ltd., Dorset House, Stamford Street, London, S.E.1. Price 42s.

Manual of Model Steam Locomotive Construction. By Martin Evans. Percival Marshall and Co., Ltd., 19-20, Noel Street, London, W.1. Price 30s.

Temperature Measurement and Control. By W. F. Coxon. Heywood and Co., Ltd., Carlton House, Gt. Queen Street, London, W.C.2. Price 60s.

Diffraction Gratings as Measuring Scales. By J. Guild. Oxford University Press, Amen House, Warwick Square, London, E.C.4. Price 35s.

Proceedings of the Symposium on Aluminium in Building. The Aluminium Development Association, 33, Grosvenor Street, London, W.1. Price 50s.

Laboratory Manual for National Certificate. By K. A. Holes. The English Universities Press, Ltd., 102, Newgate Street, London, E.C.1. Price 8s. 6d.

Decorative Cast Ironwork in Great Britain. By Raymond Lister. G. Bell and Sons, Ltd., York House, Portugal Street, London, W.C.2. Price 25s.

Guide to Belgium and Luxembourg. Eighth Edition. By C. A. Thompson. Belux Publications, 26, York Road, Holland-on-Sea, Essex. Price 6s.

Fishing Boats of the World : 2. Edited by Jan-Olof Traung. Fishing News (Books), Ltd., Ludgate House, 110, Fleet Street, London, E.C.4. Price 147s.

The Two Aspects of Science

By SIR GEORGE THOMSON, F.R.S.

We reproduce below a small part of the Presidential Address to the British Association for the Advancement of Science presented last Wednesday. Whereas most of the Address discussed Physics the paragraphs printed have relevance for engineers.

SCIENCE is a pyramid based on many varied facts, topped with a crown of ideas reaching to the skies. These are its fruit but can change without affecting its stability. I sometimes think that in philosophy the pyramid is the other way up !

What we want as scientists—I am sure in this I speak for the great majority—is that the world should realise that we are not interested merely in making possible new drugs, television sets, or weapons, though all these are important, but in enlarging the bounds of human knowledge.

The greatness of the human race is indeed many-sided. Thus in the world of art there is a difference between the ability to compose or interpret a great piece of music and that which writes a great novel or paints a great picture. Yet all are evidence of greatness and worthy of the name. Still more so is moral greatness. " There is one glory of the sun and another glory of the moon and another glory of the stars."

I have no desire to exalt our profession unduly, but surely the ability to understand, even to a limited extent, the world around him is one of the powers of which man has good right to be proud. Indeed it seems to be the one which most divides him from the animals. The lark's song, the heroism of a plover luring an enemy away from her young, the cat who was seen to attack a grizzly in defence of her kittens—these, if taken at their face value, are notable even by human standards, but I am not aware (though I speak with great diffidence) of any creature which even appears to be trying to discover any general principles.

The chance of understanding things of fundamental and permanent importance is what makes the pursuit of science fascinating and worth while.

These two aspects of science do not in fact conflict. The best way to make advances in technology, whether on the medical or the engineering side, turns out to be to understand the principles. This is quite a recent discovery, indeed it has probably only recently become true. It would not have been much use, for example, to man in the Stone Age, or even a few hundred years ago, to try to understand the principles of tanning with no basic knowledge of chemistry to guide him. He did better by trial and error. Even the steam engine was developed with little knowledge of the determining principles, though the best scientific minds of the day were much interested and the thought they gave it advanced science by discovering thermodynamics.

Electrical engineering was the first important activity to be developed from the start on scientific principles, and even here Edison did great things on a decidedly sketchy knowledge. But increasingly more discoveries are made in research laboratories and fewer by workmen on the bench. This is what one might expect. As fundamental principles get known it is possible to use their consequences intelligently. Often these consequences are too complicated to be calculated, but knowledge of the principles is an enormous help by showing in a general way what is likely to happen.

Then of course there are the modern technologies which derive directly from some important new basic discovery, such as electronics and nuclear energy.

This dependence of technology on pure science is now pretty generally recognised by industry. The more progressive industries maintain research laboratories which both make use of the basic discoveries made in the universities and elsewhere, and contribute their own. These laboratories may be owned and operated by individual firms, or be co-operative efforts of an industry in the form of Research Associations substantially helped by Government. There are black spots, of course, industries which spend too little on research or organise it badly, but broadly speaking the need is realised and reasonably well met.

Pure science receives a great return for what it contributes to technology, and this in two ways, materially and in the realm of ideas. Consider first the material return ; a modern physics laboratory could not work without instruments developed for technology and obtainable cheaply because industry needs them in large numbers. Take just two examples out of many. The use of high vacua—and how important this is—has been enormously facilitated by the needs first of the electric light industry and then of the manufacturers of radio valves. Again, the complicated electronic devices which crowd every physics research laboratory would be impossible without the cheap components of all kinds manufactured originally for radio and now for television. For this return by industry I sometimes think we academic scientists are not as grateful as we ought to be.

The other influence of technology is more subtle but as important. As science advances, concepts tend to become more and more abstract, further from anything that can literally be touched or handled. To take a simple case, energy is more abstract than mass which it replaces. In the higher flights of theoretical physics abstraction goes much further. Is there not a danger that one may lose touch with reality, and end up by supposing that some elaborate piece of mathematics represents reality when it is only a creation of the mind, inspired indeed by physical reality but no more like it than is a modern picture ? I think we are safe as long as the people who make these theories are reasonably close to them who use them, not merely in laboratories, but in industry.

A theory which involves detailed consideration of the behaviour of particles less than a millionth of a millionth of an inch across would have seemed to Swift too absurd to be even worth ridicule. Yet one cannot regard it as a pipe dream when it leads to the great reactors of Calder Hall or Chapelcross. To me, the most amazing thing about science, and the most surprising and exciting fact about our world, is this astonishing connection between highly abstruse theoretical ideas and the matter of fact, in this case the housewife boiling her kettle with power from nuclei. This surely adds an immense thrill to discovery. I have no sympathy with those who regard technology as intellectually a poor relation of science. To me science without technology is incomplete and inconclusive. Systems of philosophy come and go, some are perhaps true but who can tell ? But when conclusions deduced from precise experiments by mathematical theory lead to detailed predictions from which working machines can be designed, machines which without the theory no one would have thought of in a million years, then indeed one knows that one lives in a universe which is rational and that one has found the key to one of its rooms.

Future Techniques in Computing

IN the course of a note on future techniques in computing by Mr. A. St. Johnston, joint general manager, Data Processing Group, Elliott Brothers (London), Ltd., it is shown that, as a result of the junction transistor, machines can now achieve switching speeds an order of magnitude faster than are obtainable with valve circuits. Ultra high-speed elements recently announced by Mr. St. Johnston's company can switch from one state to another in 5 to 10 millimicroseconds. These elements are based on work done at the University of Illinois by Poppelbaum and Wiseman on an A.E.C. contract and were developed from analysis of the minimum intrinsic delay that could be achieved taking into account the basic physics of the semiconductor. Apart from physical limitations of semiconductor physics, they have reached about the limit that existing circuit techniques can achieve owing to the speed of light itself. A 5 millimicrosecond rise time implies that two elements 5ft apart could each think the other had switched after itself. Additional problems result from the radiation of effectively 200 Mc/s radio signals inside the machine.

An entirely new approach is necessary before achieving the next order of magnitude in speed. The use of microwave techniques might overcome the transmisssion problem and the Paremetron could serve as the active element in this type of system. At one stage it looked as if the tunnel diode might make possible the development of circuits in conventional form operating with a 1 millimicrosecond rise time. However, it will probably be some time before machines using tunnel diodes make their appearance with higher speeds than transistor machines. The physical size problem affects the tunnel diodes as much as the conventional transistor.

The eventual target in microminiaturisation is to have completely machine-made circuits, or even equipments, where individual components in the conventional sense do not exist. The basis may be a semiconductor crystal into which are etched leads, resistor paths and other non-active circuit elements, the diodes and transistors being formed by appropriate dopings. Microminiaturisation may also result in faster speeds, particularly if the elements are immersed in liquid helium. Thus the next stage of really new techniques is cryogenics. The fundamental effect of super-conductivity is brought into play in cryogenic elements, which are used at temperatures so low that the conductors have literally zero resistance. They can be made resistive by the application of a magnetic field or by a slight increase in temperature. By this means bistable elements, gates and memory cells, which are the basic computer bricks, can be produced. However, this technique may take years to evolve to a stage where it is possible to construct a complete computing machine. The cryogenic elements themselves require to be very thin films of materials which are difficult to reproduce reliably apart from the problems of maintaining the very low temperatures.

Thin films of magnetic material which consist of a single crystal domain lead to another possible series of computer elements on which much work is being done both in this country and the U.S.A. These films may be deposited *in vacuo* or electrolytically and lend themselves to being etched in very fine patterns even possibly under the control of an electron microscope, thus resulting in complete circuits being invisible to the human eye.

The British Steam Locomotive Since 1900

By W. A. TUPLIN, D.Sc., M.I.Mech.E., A.I.Loco.E.

Soon after the beginning of the twentieth century, the superheater and the piston valve were generally accepted as desirable features in the steam locomotive and compounding was generally abandoned as offering no overall advantage. The steam locomotive in Britain had then reached its limit of development in basic principle. Selection of dimensions of valves for locomotives seems to have been by guesswork in most cases and at least twenty years elapsed before there was general acceptance of what had been shown to be right. The virtues of simplicity have become more highly valued with lapse of time, but even with over a century of experience, unrecorded variations in local operating practices make it impossible to guarantee that any new design feature, however carefully considered, will satisfy everyone or even a majority.

RECENT completion of the last steam locomotive to be built for British Railways gave rise to the comment that the 2–10–0 of 1960 is the same in principle as Stephenson's four-wheel " Rocket " of 1829 and to reflection on the remarkable fact that well over a century of wide advances in science and technology have failed to improve on this particular form of steam power plant for its own original purpose. This emphasises again that mechanical engineering is primarily practical, and suggests that this section of it owes little to academic science. This is undoubtedly true, but here and there in the history of the steam locomotive there were occasions when a sure grasp of a few basic facts of physics could have deterred engineers from expensive and abortive experiments in iron and steel. (A sidelight on this is the inadequate sizes of train-heating steam boiler fitted to diesel locomotives in recent years).

Elementary mechanics and thermodynamics such as the present-day schoolboy learns as a matter of course were subjects for controversy among scientists when the steam locomotive appeared 150 years ago. Those who designed and built the earliest examples had no knowledge of those subjects or of what we have since come to call " strength of materials." They had to guess and to keep on guessing better and better as experience with locomotives accumulated. This is what they did and it is what locomotive engineers, by and large, have done ever since. The steam locomotive developed more rapidly than did general understanding of basic physics, and as there is no critical element in proportioning its major dimensions, and as by its nature it is adaptable in service, its designers have never been compelled to study the fundamentals of its operation. Those who have done so sometimes tend to regard the subject as more complicated than it really is.

As time went on everything conceivable was tried by someone or other and before the end of the nineteenth century any engineer could design and build a successful steam locomotive after examining the constructional features and performance of a wide variety of good and bad designs. Indeed, the very number of designs was great enough for new ones to have been developed by a statistician without using any knowledge of mechanics at all. A design that could be guaranteed to remain unsurpassed could be produced by a locomotive engineer who made full use of conclusions reached after rational analysis of all available information on design and performance in the nineteenth century. This was possible but it was rarely done because exhaustive study of existing information is laborious and because a locomotive engineer could produce a passable design for any particular duty by enlargement or modification of the design already in use on the same railway for a similar but lighter duty. There is some technical advantage in this, if the preceding practice is sound, besides the personal pride in apparently owing nothing to anyone else. In broad principle, however, it is clearly inefficient for efforts to be expended by many people in producing different designs for the same essential purpose. In the first half of the twentieth century the number of new designs of locomotive for use on the railways of Great Britain was about 600, whereas the entire range of duties could have been covered by twenty. It is easy to say this now, and it may have been less easy to realise it in 1900, but it was, in fact, done, and the appropriate action taken, by Churchward on the Great Western Railway.

In 1901, the main lines of future locomotive construction for the Great Western Railway were laid down. In about six years, new standard designs based on a small number of standard components were built and tested, and with a few obvious developments in size, these covered all requirements for fifty years on an extensive railway system with nearly every British sort of operating condition except hump-shunting and 400-mile through-working. This was done with sixteen designs and so it is safe to say that all Britain could have been covered by twenty.

It is interesting to reflect that if all British locomotive superintendents had got together in about 1900 and agreed on the development of the minimum number of standard designs for everybody, one result would have been to avoid the waste of time and effort that have been expended on 580 superfluous designs.

By contrast to such rational procedure, local resistance was shown to the reduction in number of standard designs that began with the railway grouping in 1923. It was stoutly held by some, for example, that a locomotive designed in the south of England could not really cope with conditions in Scotland. This in itself is nonsense, and yet it is found that a standard design may have in some part of Great Britain troubles that it does not suffer anywhere else; the explanation lies not in geography, but in unrecorded peculiarities in local operating practice.

It is fair to say that in 1900 the steam locomotive was entering on its last stage of development inasmuch as superheating and piston valves were being brought into sound practical form. Neither these nor any other feature in the steam locomotive then or now was less than fifty years old, and indeed one trend in the twentieth century was to bring the British steam locomotive closer to Stephenson's " Rocket " than it had been in the intervening seventy years. This was the reversion to outside cylinders, adopted by the pioneers because of the obvious simplicity of the associated construction and directness of drive to the wheels, but largely abandoned in Britain because of the swaying effect of their reciprocating masses on locomotives of short wheelbase. The B.R. 2–10–0s are nearer still to the " Rocket " by virtue of the inclination of their cylinders.

Compounding

Another feature of British practice in 1900-1910 was the trial of compounding just after the London and North Western Railway, the British pioneer in this field, had emphatically rejected it. It is true that compounding was never given a fair chance on the North Western because it was applied without real understanding, but nowhere in Britain was it found to be worth adopting except on the Midland Railway, where it was built into locomotives larger than the single-expansion engines employed on similar work. The three-cylinder compound system used on the Midland and afterwards on the L.M.S. was adopted in France some forty years later, after more than sixty years' faithful adherence there to four-cylinder compounds.

It is difficult to know now whether the earliest users of compounding in locomotives (e.g. Webb on the North Western) had any clearer idea of the possible advantage than the vague one that if the same steam were used twice over, more work would be obtained from it. This would certainly be the case if by compounding, a higher expansion ratio were obtained than was practicable in single-stage expansion. In actual fact the most successful compound locomotives used expansion ratios that were readily practicable in a single stage and their advantage (of the order of 10 per cent) in thermal efficiency was due solely to limitation of expansion ratio, and therefore of temperature-range, in any one cylinder. (The uniflow single-expansion engine has this same advantage, but the uniflow principle found no successful application in locomotives.)

This discredits the opinion frequently expressed, that compounding is necessary or desirable to " take advantage of high boiler pressures." On the contrary, adoption of the compound principle in a large locomotive enforces the adoption of a higher boiler pressure than would suffice for the same duty in a single-expansion engine, because the compound needs space for high-pressure cylinders in addition to low-pressure cylinders of the same dimensions as would suffice for the simple. So space limitations make high boiler pressure a necessity in a large compound, whereas the casual commentator tends to look upon it as a virtue.

A frequent suggestion has been that as stationary steam power plant practice has adopted boiler pressures up to 2000 lb per square inch, and more, locomotive design might profitably develop in the same way. This shows failure to realise that while every rise in boiler pressure in steam power plant that exhausts to a high vacuum means an increase in expansion ratio and therefore in possible extraction of work from the steam, this is not true of the conventional locomotive, for there the expansion ratio cannot be gainfully increased beyond about 4.

Some advantage in thermal efficiency was certainly to be gained by designing a compound to work in each stage at the highest expansion ratio that is useful in a simple, but

to achieve a worthwhile advantage, interstage reheating is necessary and in a locomotive of high power, space restrictions in the low-pressure cylinders force the initial pressure above the practicable limit for the conventional locomotive boiler. Gresley's 4–6–4 No. 10000 of 1929 was apparently conceived on this basis, and had a water-tube boiler rated at 450 lb per square inch. It had no re-heater and although the need for it may have been avoided by the high initial steam temperature that the original superheater was capable of producing, that temperature introduced practical difficulties and a lower one was substituted. Neither in power nor thermal efficiency did this locomotive equal the performance of the lighter and less expensive standard Gresley "Pacific."

Expansive Working

It had long been recognised that, except for cut-offs earlier than about 25 per cent, the higher the ratio of expansion in the cylinders the higher the thermal efficiency. To take advantage of this fact, large cylinders were necessary and towards the end of the nineteenth century some trends in design could be construed to have arisen from this thought. The good intentions (if such they were) were, however, often thwarted by the fact that the cylinders could not use the full boiler output if the cut-off were adjusted to give the desired high expansion ratio and might exhibit uncomfortable big-end knock in that condition. This was simply because the valves were not large enough to pass steam at the necessary rate through the narrow port openings at early cut-off and that if this defect were diminished by adopting a greater lead, the consequently early pre-admission of steam produced knock. In short, valve dimensions were not, in general, properly considered and the practice of making the width of a flat valve about equal to the cylinder diameter in conjunction with a lap of an inch or less, whilst tolerable for 16in cylinders worked at 35 per cent cut-off, became quite useless for 20in cylinders if it were attempted to work them at 20 per cent.

The ideal that was being sought was, in fact, unattainable with large cylinders and slide valves. It needed piston valves of dimensions properly related to the cylinder dimensions and to the power and speed required. Churchward on the Great Western had found the solution by 1905, but even twenty years later there were locomotive designers who were still hazy about it, and forty years had to elapse before the essential basic principle was expressed in a rational designer's formula.

In the meantime the absence of such a formula did not prevent steam locomotives from being designed, built or operated, as they are not sensitive to imperfections in concept or construction, but it did mean that some of them could have been made appreciably more efficient at no extra cost. The original Gresley "Pacifics" were in this category, and the circumstances were such as to suggest that the importance of valve dimensions had not been appreciated when the design was prepared. For the 20in cylinders of the "Pacific," valves only 8in in diameter with only 1¼in lap were provided, and their best speed range[10] was about 25 to 50 m.p.h. Thirteen years later, Gresley produced the "A4" "Pacific" with valve/cylinder proportions giving a best speed range of about 42 to 84 m.p.h., and no British design has surpassed this for heavy fast passenger train service. But if the significance of valve dimensions had been appreciated when the original "Pacific" design was being prepared, the year 1922 could have seen the performance of the 250 lb "A.4." produced by a 180 lb "Pacific" weighing some 6 tons less and cheaper in first cost and maintenance.

It is very easy to be wise after the event. The significant "event" here was the demonstration by the performance of Churchward standard designs of the value of rational valve dimensions. The exact date of this event is debatable, but it was certainly before 1922. What was required was not mere copying of what Swindon had done, but understanding and application of the principle demonstrated.

Piston Valves

Although there had been intermittent dabbling with piston valves before 1900, superheating made them appear imperative and every major British railway had some by 1910. Many early steps in this direction were bedevilled by the obsession that the automatic pressure release feature of the flat valve must be secured for the piston valve by gadgetry inside it. Not immediately was it concluded that the right answer was a plain piston valve with cylinder-end relief valves. Not immediately was it realised, even with the piston itself as an example, that valve leakage is reduced by substituting a number of narrow rings for two broad ones. Only the Western Region retains steam-expanded valve rings and these were designed early in the century on the basis of an American model.[7] Churchward was bothered at times by carbonisation of valves and this demon still remains incompletely exorcised.

Poppet Valves

The successful use of poppet valves in internal combustion engines led early in the century to their trial in steam locomotives. The possible saving of power by avoidance of friction as in piston valves perhaps justifies the extra complication, and an improvement in steam distribution is superficially made possible by independence of the movements of the inlet valves and exhaust valves. In fact, this latter advantage is negligible because, as it happens, piston valves worked by conventional valve gear can be designed to give a very good practical approximation to the theoretical ideal. Poppet valves have been adopted in various places with enthusiasm based on their low maintenance cost. They had an impressive vogue in France where, however, they were later abandoned because their maintenance cost was higher than that of piston valves.[4] They were also abandoned by the German State Railway before World War II and the ups and downs of poppet valves in Britain have left no lasting conviction that they are superior to piston valves.

Superheating

The turn of the century saw the Schmidt type of superheater under successful trial and it had become generally accepted by about 1912. In the conventional steam locomotive the advantage of superheating lies in its elimination of condensation in the cylinders. Superheat higher than is necessary to do this at the highest full-power expansion ratio confers no advantage beyond a saving in water. (Here, as in the matters of boiler pressure and expansion ratio, it is tempting but wrong to assume that because a little of something is good, a lot of it must be better.)

This was appreciated at Swindon and there the standard designs were characterised by rather small superheaters that were, however, adequate in good operating conditions. To cover imperfect conditions such as partial blockage of flues with char, it is useful and not detrimental to fit a superheater larger than the ideal minimum and that is normal practice.

Multiple Cylinders

Apart from what was done on the Midland Railway, compounding had no lasting effect on British locomotive practice, but the trial of French-built four-cylinder compounds on the Great Western did bring into notice one advantage of using more than two cylinders. This is that, even with small reciprocating balance weights, the engine may be made to run more smoothly than is possible if it has only two cylinders. It was this feature of four-cylinder compounds that led to the trial and adoption of the four-cylinder simple on the Great Western. Without the same stimulus, a four-cylinder simple 4–4–0 was built for the Glasgow and South Western Railway in 1897; it ran for over twenty-five years in that form and for a further twelve years with a larger boiler, but its virtues were not great enough to justify any reproduction on that railway.

The idea that the use of three or four cylinders instead of only two makes the engine more powerful may at first sight be dismissed as excessively naïve in that "power" is essentially boiler power. Further consideration shows, however, that in one sense the suggestion can be supported. If, in fact, maximum power is being sought within given limitations of size and weight, then the maximum cylinder-volume must be obtained, and so it is necessary to use four cylinders if not more. With three or four cylinders, reciprocating balance weights are unnecessary, there need therefore be no hammer blow on the track and the total weight of the locomotive may therefore be greater than would be permissible with only two cylinders and unavoidable hammer blow. Moreover, four cylinders may have a greater total volume than any smaller number and so the working steam pressure may be lower, for any desired effort, than two or three cylinders would require. Hence the boiler, the source of power, may be larger than would otherwise be permissible within the same total weight.

It is not established that any British multi-cylinder design was conceived with this in mind, and it was certainly not so with the very last one, the B.R. three-cylinder 4–6–2 "Duke of Gloucester." There the cylinders might have been larger, the working pressure lower and the boiler therefore lighter and less expensive in manufacture and maintenance. The same is true of most other British multi-cylinder locomotives and it seems strange that this way of offsetting the disadvantages of multiple cylinders was not adopted.

The three-cylinder simple was initiated in twentieth century Britain by the Great Eastern well-tank 0–10–0, of which the most remarkable feature was the inside connecting-rod made in the form of a frame encircling the leading axle merely to dissipate the designer's fear of some imaginary disadvantage in an inclined cylinder. In special tests of acceleration this locomotive agreed with the expectations of elementary mechanics but never hauled any revenue-earning train. By contrast, the Great Central three-cylinder 0–8–4 tanks, built largely of standard components, were employed for nearly fifty years in hump-shunting at Wath near Barnsley. The North Eastern used three-cylinder 4–8–0 tanks for similar duty and afterwards built many different locomotives with three cylinders. No one else used the North Eastern layout, including a crank axle

congested with six eccentrics and under-boiler space ahead of it packed with mechanism, but Gresley's Great Northern system with outside valve gear and no eccentrics at all was successfully applied on the L.N.E.R. No other organisation, however, made any extensive use of the principle of operating the third valve by mechanism driven by the other two.

The merits of three-cylinder and four-cylinder layouts are nearly balanced, but the latter has the disadvantage of much more severely restricting the width of the crank axleboxes. Three-cylinder locomotives built for British railways have been more than three times as numerous as four-cylinder locomotives. A few of the latter have had cranks set to give eight exhaust beats per revolution, but with no discernible advantage.[3]

By post-1939 standards, multi-cylinder locomotives tend to be regarded as "luxury models" replaceable for the most part by less expensive two-cylinder designs, some of whose disadvantages are mitigated by reducing the proportion of balanced reciprocating parts and by laying heavier rails.

Boiler Pressure

In the B.R. "Britannia" "Pacific," it was necessary to use a boiler pressure of 250 lb per square inch in order to secure the desired nominal tractive effort with the selected size of driving wheels and the largest practicable two cylinders. In the G.W.R. "King" of 1927 the same pressure was adopted for the same reason with the largest four equal cylinders that were practicable in the very restricted de Glehn layout that Swindon convention enforced. (The inside cylinders could have been larger than those outside the frame, but Churchward might not have approved.)

In parallel with these examples of high boiler pressure adopted as a technical necessity (the only sound reason) there have been many cases of unnecessarily high pressures adopted for compliance with fashion or, in more dignified words, for reasons of prestige. This may be hotly denied, but it is a phenomenon that has also been noticed[13] in another branch of steam-power practice.

On the Southern Railway, the "Pacifics" were given 280 lb boiler pressure in 1941 and the Great Western equalised with the "1000" class 4–6–0s in 1945, but in both cases, 250 lb was later substituted. On the L.M.S. a wholly unnecessary 300 lb was contemplated in a 4–6–4[12] that was, fortunately, never built.

Other things being equal, rise in the designed working pressure of a boiler of any specified power leads to greater weight, prime cost and maintenance cost. In particular, advance beyond 200 lb per square inch has been mentioned as noticeably detrimental in the last respect,[5, 6] but these disadvantages have been accepted as part of the price to pay for keeping up with the Joneses.

The lack of any appreciable advantage from unnecessarily high boiler pressure is one of the facts that the casual student of this subject contests bitterly. He has genuine difficulty in believing that the energy in a pound of steam at any specified temperature is the same whether its pressure is 1 lb per square inch or a thousand times as much. He cannot see why the speed of steam through a suddenly-opened port should be determined by the temperature of the steam and not by its pressure.

There is no thermodynamic advantage in raising boiler pressure above about 180 lb per square inch[1,3a] but it does pack every pound of steam into smaller volume and this is useful where space is limited.

There are on the other hand, substantial rewards for keeping down the boiler pressure. For example, the excellent LMS Class "5" 4-6-0 could have been designed for 180 lb. instead of 225 lb. working pressure and if the consequently possible saving in boiler-weight had been used to thicken the frame-plates, cracking of frames could have been eliminated from this class (see Ref. 15, pp. 84, 148, 174 and 175).

Multiple Exhaust

A plain blast-pipe and single petticoat pipe can be designed to draw from any British locomotive the maximum power normally expected from it in reasonably good working conditions and no front-end modification, such as the use of multiple exhaust, can perceptibly improve on it. This explains why trials of multiple exhausts on British locomotives before 1940 did not lead to any wide adoption of them. On the other hand, they were employed to striking effect in France where locomotives were habitually worked much harder than is or was common in Britain. Similarly, no justification could be found for including them in the British Railways standard designs developed after 1948. On the other hand, deterioration in fuel and maintenance in and after World War II led to the application of multiple exhausts to some existing designs.

As a single blast-pipe can be designed to work any British locomotive at well above normal British combustion rates with a blast-pipe pressure of about 8 lb per square inch above atmosphere, the absolute limit of possible proportional gain by any other draughting arrangement is the ratio of 8 to the mean effective pressure in the cylinders. In practice, multiple exhaust does not gain more than about 4 lb per square inch in mean effective pressure.[14] The greatest advantage is therefore where the mean effective pressure is low, as at high speed or in a locomotive with low boiler pressure. Yet the vast majority of British applications of multiple exhaust have been to locomotives with boiler pressures of 220 lb per square inch or higher.

In practice, replacement of a single exhaust by a multiple exhaust has often led to a much greater advance in apparent maximum output of a locomotive than can be explained by reduction in back pressure. The probable reason is that the softer sound of the low-pressure exhaust induces the driver to work the engine at power outputs from which the sound of a single exhaust might deter him. If the fireman also fails to realise the intensity of draught created by even a quiet multiple exhaust and overlooks the resultant high power output, he may be led to believe and to report that the engine burns a lot of coal.

Estimation of power output by direct measurement of blast-pipe pressure instead of judgment by sound is the basis of a very successful Swindon system of testing locomotives on the road.[11]

Wheel Arrangements

The outside cylinder 4–6–0, first tentatively adopted in Britain for fast passenger train service near the turn of the century, is still widely employed in that capacity. With a wheel diameter of about 6ft however, it is now usually described as a "mixed traffic" locomotive and the first example of its present form was the "483" class introduced by Urie on the South Western in 1913. This was a 4–6–0 with a superheater, two cylinders (outside) and piston valves worked by Walschaerts gear. The valves were not large enough to feed the cylinders adequately at high speed and early cut-off and so even the large-wheeled version of this design lacked the sparkle of speed shown by Great Western 4–6–0s of comparable size. This defect has been avoided in more modern mixed traffic 4–6–0s, of which there are more than 1700 in Great Britain.

Since 1922 British 4–6–2 locomotives have gradually increased in number to nearly 500, and in addition there are some 180 Gresley 2–6–2s of similar power capacity. British railway traffic has never warranted such large numbers of such large locomotives unless it be accepted that service conditions are so bad as to limit most of these locomotives to power outputs within the capacity of 4–6–0s of thirty years ago.

The presence of non-driving wheels at the rear of a locomotive makes the adhesion weight uncertain in general and sacrifices the positive increase that the backward pull of the drawbar otherwise produces. For these reasons, "Pacifics" and 2–6–2s are less effective in starting from rest than are 4–6–0s of the same adhesion weight. Complaints about persistent slipping of "Pacifics" at 30 m.p.h. and over probably originate in sanding gear inadequate for such a speed.

The 4–2–2 and 4–4–0 wheel arrangements, widely used for British passenger trains in 1900, have given place to 4–6–0s and 4–6–2s, the 4–4–2 having been adopted and abandoned in fifty years. On the freight side, changes have been less marked, much work still being done by inside-cylinder 0–6–0s as for a hundred years past and a number of 0–8–0s also remain in service. Reversion to outside cylinders caused these wheel arrangements to be superseded by the 2–6–0 and the 2–8–0. Locomotives built for the War Department during World War II introduced the 2–10–0 to Great Britain and it is now represented by the numerous, and highly regarded, B.R. class "9."

For shunting and other short-distance freight work there has been little need to depart from the 0–6–0T, and even as late as 1953 the Western Region was using this wheel arrangement in new "wet-steam" flat-valve locomotives that are pure Stephenson except for the pannier tanks which are pure Swindon.

In the ten years preceding World War I there arose a fashion of large tank engines for fast passenger train service, and this culminated in the four-cylinder 4–6–4T built at Horwich for the L.M.S. in 1924. None of the larger locomotives of this cult seems to have been strikingly successful. On the other hand, the Great Western 2–6–2T was built in considerable numbers for suburban and branch-line service, but on the other lines the 2–6–4T has been more widely adopted because of its greater bunker capacity and the aim to make every locomotive able to do a full day's work without intermediate refuelling.

Some Details

The grouping of 1923 afforded opportunities for official comparison of details of design and construction used by different railway organisations and some remarkable varieties of imperfection were discovered. On the L.M.S., for example, E. S. Cox examined[2] different designs of axlebox, none of which equalled the performance of the Swindon design adopted by Stanier. A significant point in this design was its avoidance of holes and grooves in the loaded area of the journal; the classic experiments of Beauchamp-Tower in 1883 should have impressed the importance of this on all designers.

An investigation[8] on coupling-rod loading revealed a ratio of 5 to 1 in different designers'

estimates of the safe compressive load on such a rod. Perusal of the discussion on the same paper leads to the conclusion that the common adoption of the I-section for coupling-rods is a mistake as they almost invariably fail by lateral bending and not by excessive stresses due to centrifugal force. The original rectangular section from which the I is produced by milling is very much stronger and therefore is less easily bent. This was discovered at Swindon in 1906 when the rectangular section was therefore standardised, but elsewhere much time and effort have been expended on weakening coupling-rods by high-power milling.

Lightening of coupling-rods and connecting-rods by adopting thin sections of alloy steel has not been universally accepted as desirable; substitution of alloy steel for mild steel makes no difference to the resistance of a rod to buckling under axial load or to its axial stiffness, which is a vital factor in certain natural vibrations that are suspected to be the cause of certain types of failure of coupling-rods.[8, p 586]

The inevitable dynamic unbalance in a two-cylinder engine makes its riding very rough and uncomfortable when wear has produced appreciable play of axleboxes in hornblocks. In the L.M. Region the rate of wear at these points was considerably reduced by using liners made of manganese steel, and the mileage of L.M. class "5" 4–6–0s between successive major overhauls was thereby increased by about 35 per cent. This is a good example of a small detail-change that produces a substantial economy in running cost.

Even in so advanced a design as that of the Gresley streamlined Pacific of 1935, the inside big-end was liable to overheat unless kept adjusted with special care, but it was made far less sensitive in this respect by a trifling detail change effected a few years ago. As an intermediate palliative the big-ends were loaded with a chemical that generates a smell like garlic when a particular temperature is exceeded in order to tell the driver that trouble is brewing.

Provision for Enginemen

The user of almost any machine occasionally wonders whether the designer himself ever expected to be compelled to use it or to repair it, and enginemen are often constrained to believe that the designer of a locomotive adds the cab and footplate in whatever space may be left when everything else has been considered. The position is rarely quite so bad as that, but it must be conceded that some cab arrangements suggest little appreciation of the details of enginemen's working conditions.

It is common, for example, for coal to be delivered to the fireman at footplate level, although it could just as readily be at firehole level. Stroudley did this in the nineteenth century and so did Bowen-Cooke in the twentieth. British Railways also do it in conjunction with the Great Eastern practice of extending the footplate back over the gap between the engine-frame and that of the tender.

Fire-door designs are barely credible. On the Great Western the door is normally left open, but the fireman hauls a half-height flap-plate up in front of the opening after every shovelful of coal. On the L.N.E.R. a butterfly plate is pivoted on a horizontal axis at mid-height of the opening so as to combine maximum obstruction for the shovel with maximum access of air. On the L.M.S. and B.R. the door is in the form of two heavy box-form double-deflector plates which, even when pushed in front of the opening, do little more than reduce emission of light. On the Southern the most notable form of fire-door is in the form of two wings normally covering the opening but moved away by steam power when the fireman depresses a pedal from its running position about 8in above the floor. Release of the pedal causes the doors to close and this can readily be done after feeding every shovelful of coal. The need for the fireman to stand on one foot while reaching for the pedal with the other, and the occasional premature closing of the door while the fireman's hands are near it, have been regarded as disadvantages.

(All the necessities in this detail are covered by a mechanism of elemental simplicity that allows the fire-door to fall open by gravity when a trigger is loaded by side pressure from the sole of the fireman's shoe and that allows the door to be closed by the shovel immediately after each "shot.")

Although every widely used variety of fire-door and, indeed, of every other cab-fitting can be criticised on one score or another, the practical effect is less than might be expected because human beings can get used to almost anything and eventually cease to complain. This may allow the responsible designer to forget the matter, but it still leaves an element of inefficiency in the operating conditions.

Some designs of locomotive have failed to come up to reasonable expectations simply because they had features that made them unnecessarily difficult to fire properly. A good fireman in a good humour could make them perform creditably, but most firemen are unable or unwilling to take special interest in counteracting the results of a defect in design and so the class of locomotive retains an indifferent reputation, no matter what other modifications may be made to it in the absence of recognition of the real fault.

Even with every good intention in the designer, the utility and convenience of any new assemblage of cab fittings seems impossible to predict and difficult to assess even after trial. Enginemen have often accustomed themselves to unnecessary awkwardness before any report about it has penetrated to anyone willing and able to alleviate it and, indeed, there can be widely different opinions about every aspect of footplate work. Some firemen, for example, will complain if the firehole deflector plate is not so long as it ought to be, while others will throw it overboard whatever its length.

The designer of British Railways standard cabs could never hope to suit every engineman, but a determined attempt was made to combine what seemed to those in authority to be the best of existing arrangements.

The mounting of the cab on the boiler of each tender engine instead of on the frame would seem to be sound practice, and it is probably wrong to blame it for the exceptional noise in B.R. cabs of this type.

General Design Policy

The abundance and low cost of labour in 1900 made it unnecessary to develop really economical designs and left designers free to comply with certain current conventions. An ideal at that time was to present a smooth exterior and to this end components of locomotives were concealed in spite of the resultant rise in cost of maintenance. Examination of sixty-year-old drawings shows almost incredible examples of this; a very remarkable case was the positioning of London and North Western injectors under the footplate in a narrow space between the ash-pan and the rear coupled axle. The reliability of the Crewe injector evidently inspired a faith that no modern design can equal.

In some other countries there was more enlightened thinking on the subject of accessibility, and when it spread here the resultant rational designs perturbed amateur admirers of the age of concealment and even some professionals suffered nameless fears.

There were a few attempts to ease the lot of those who did the most unpleasant regular jobs on steam locomotives, such as fire-dropping and smokebox emptying. There was evidently no economic necessity for this as very crude methods of fuelling and emptying locomotives are still in common use, but it is nevertheless possible that full scale mechanisation of locomotive shed work would have paid for itself in the past.

Only very limited use has been made here of special feed-water treatment[4] that has very markedly reduced locomotive boiler maintenance costs in France since 1939. Similarly, there are very few duplicates of the locomotive inspection chamber introduced in Britain during World War II. In this chamber, under a ventilated roof and over a pit, stands every locomotive for a few minutes on returning to the shed, while every part is strongly lit to facilitate discovery of such defects as loose or missing nuts.

The only general improvement in design to facilitate daily servicing has been the wider use of rocking-grates and self-emptying ash-pans since World War II than there was before, but even now they are uncommon outside their universal application in B.R. standard designs. The self-emptying smokebox, designed so that half-burned "char" is thrown from the chimney instead of accumulating in the box, has not won universal commendation in this country; it is not always possible to apply the self-cleaning principle without detrimental effect on the draught through the fire.

The "individual costing" procedure applied on the L.M.S. gave, probably for the first time, reasonably reliable figures for the running costs of locomotives and showed marked disparities between designs inherited from various constituent companies of the L.M.S. group. Information of the same sort was invaluable when the time came to design new British Railways standard classes after nationalisation in 1948. Although by this time each of the four groups had developed sound designs for the ordinary classes of railway haulage, it was deemed desirable, for non-technical reasons, not to adopt any of them but to draw up an entirely new set of designs with maximum interchangeability of components, just as Churchward did nearly a half-century earlier. As in his practice, every B.R. design had only two (outside) cylinders; in addition outside Walschaerts valve gear is a B.R. standard feature whereas in 1901 it had not been thoroughly tried out in America and so Churchward adopted Stephenson gear as was common there.

Sound reasons were produced to show why no British Railways locomotive should have multiple exhaust or more than two cylinders, or anything but piston valves, but old habits prevailed in the end to the extent of the building of a single three-cylinder "Pacific" with poppet valves and double chimney.

The last B.R. design, the class "9" 2–10–0 for freight service, has had occasional use on passenger trains, and with them has sometimes touched speeds up to 90 m.p.h. This has naturally suggested that here is the perfect all-purpose steam locomotive, but those in authority have frowned on speeds higher than 60 m.p.h. with these engines. Over the last century there have been repeated examples of high speeds by freight engines followed every time by the hint that the case for large

driving wheels was thereby disproved. What the enthusiast overlooks is the difference between an occasional sprint and a class of duty that demands comparable speed regularly. Greater wear and tear is to be expected with marked rise in rotational speeds of the driving wheels and this in itself would justify the practice of adopting the largest possible driving-wheel diameter when designing for high-speed service.

Streamlining of locomotives is a prestige feature that has been largely dropped. The Great Western was the first in Britain to try it and the first to discard it. It has been retained (apart from a detail) on the Gresley "Pacifics" to which it was applied in 1935-38 and which were used before 1940 on services with average speeds perhaps high enough to make its power-saving perceptible. On the L.M.S. and the Southern Region it has been abandoned, and so British practice shows that this particular idea of George Stephenson's is not in fact worth while.

Despite the general excellence of B.R. designs (and many others in wide use), no more steam locomotives are to be built for British Railways. It is not that the real running cost of steam locomotives need be significantly higher than that of any known alternative, but rather that they do not fit in well with the modern practice, following a long lead by the automobile industry, of designing machines so that they can be handled by people of poor physique and low mentality. The steam locomotive at its best demands of operating staff qualities higher than now suffice to produce a comfortable living in other industrial spheres, and so it sets its owners an exceptionally severe problem in recruiting labour of adequate quality in adequate quantity.

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Light Aircraft for Freighting

THERE has been announced by the Light Aircraft Division of Short Brothers and Harland, Ltd., a freighter for 3000 lb payload with the ease of loading and facility for air-dropping that are now expected with heavy military transports. The SC-7 "Skyvan," which is designed around a highly functional box-shaped fuselage, traces its ancestry from the Miles "Aerovan"; it will be recalled that the firm of Hurel-Dubois and Miles (Aviation), Ltd., demonstrated at the S.B.A.C. Exhibition in 1957 the HDM-105, an "Aerovan" with a high aspect ratio wing and lifting bracing on Hurel-Dubois principles, and projected a larger version with two horizontally opposed engines, the HDM-106 "Caravan." It proved impossible to finance this project, and concept and design were sold to Short Brothers and Harland, Ltd. The latter considers that 600 yard fields are so widely available that the extra expense of S.T.O.L. performance would not enhance the market prospects for the machine (the Miles project was visualised as having application in such adverse environments as colonial warfare in Africa) and so the aspect ratio has dropped to 11·1, the plan form remaining rectangular, and a laminar flow section been adopted; the increase in induced and reduction in profile drag have raised the minimum power speed roughly 100 per cent, so the flaps-up stall, power on, is now 55 knots and the final approach speed 80 knots. It should perhaps be interpolated that the attainment of laminar flow is not critical to the performance, the section being chosen rather to yield a wide range of C_L at low C_D—it is N.A.C.A. 63_4-614—rather than in the expectation of delaying transition right across the span, and, in fact, the skin panels are butt-jointed with external cover straps. The new aircraft has been designed for equal take-off and landing distances of 577 yards at 5000ft and I.S.A. +30 deg. Cent., the balanced field length for air-line operation in this case being 1066 yards. Our illustration shows that the inward-hinging door necessary for air-dropping gives the fuselage very much the shape of an aerofoil, and the stability and control problems centred on the pitching moments induced by the fuselage; it is anticipated that control effectiveness will not circumscribe the flight envelope, to the extent that there should be 8 deg. of elevator travel still available at the stall, and that the c.g. range will allow a tolerance of nearly 4ft on the c.g. of a 3000 lb load.

While the machine may appear primitive, the design avails itself of advanced techniques where they are appropriate. The engines are Continental GTSIO-520 flat sixes with direct fuel injection and a rated altitude of 10,000ft, so that operation is practical virtually anywhere provided airframe icing beyond the capability of the chemical systems on propellers and aerofoils is not encountered. The accurate contours demanded for laminar flow are obtained by extensive use of bonding, the skin panels being composed of a corrugated sheet with the "crests" flat and bonded with "Redux" to a smooth outer skin—the result may be likened to a Junkers W.34 or Ford Trimotor panel with an aerodynamic surface added. The ribs or formers pick up the panel at the "crest" and are riveted through. The panels are bonded in an autoclave, but for repair in the field it is intended that the outer surface should have a patch attached by cold bonding and the inner, stabilising sheet be mended with angles attached by blind riveting. This construction explains the predominance of surfaces with straight parallel generators, the corrugated sheet running from end to end of, say, one wing, and the outer skin running at right angles and being graded in thickness according to the load. This construction is expected, because of the absence of stress-raisers at fastenings, to be highly fatigue resistant, since the aircraft will be sold with a guaranteed safe life.

The fuselage has an available volume 6ft 6in square by 16ft long, the floor being strong enough for 150 lb per square foot anywhere and 300 lb per square foot in the centre; it is provided with combined lashing points and seat attachments. This space is large enough to accept the biggest vehicle within the 3000 lb maximum payload, a Citroen "Safari." So that the full width of the hold can be occupied by freight, doors at floor level open outward to give access to the lashings. The floor is at less than truck-bed height, 2ft 2in, and jacks are provided under the rear sill to prevent its height changing with load. The fuselage can accommodate up to fifteen passenger seats (with a toilet and pantry over the rear door), twelve stretcher cases, twelve armed parachute soldiers, or crop-dusting or -spraying apparatus. A roller conveyor on the floor will allow loads up to 5ft high and about 2800 lb in weight to be parachuted down.

The flight deck is designed for a crew of one, although dual control can be provided. Particularly comprehensive is the radio equipment, which is allotted the space between the seats normally occupied by the engine controls, which on this machine are in the roof conveniently near to the engines. The radio equipment is to one of two ordained standards, v.h.f. communications and v.o.r. navigation or h.f. communications and a.d.f. navigation; the actual equipment has been selected from the best available and is predominantly of United States origin.

The aircraft is sufficiently powerful to attain the B.C.A.R. second sector climb gradient of 2·4 per cent at 5000ft and I.S.A. +30 per cent with 200 lb to spare, and has been stressed for an all-up weight of 9000 lb, so it is expected to evolve into a 2 (short) ton freighter.

Leading Particulars

Overall dimensions

Length	38ft 11in
Span	64ft 1in
Height	13ft 10·3in

Fuselage

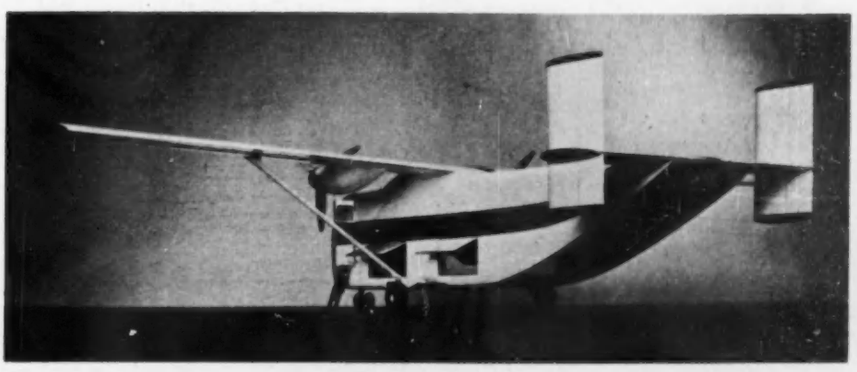
Gross internal volume	1195 cubic feet
Crew compartment volume	132 cubic feet
Main hold volume	680 cubic feet
Main hold floor area	104 square feet

Aerofoils :	Wing	Tailplane	Fins
Gross area	373 sq. ft	83 sq. ft	79 sq. ft
Span	64ft 1in	20ft 3in	9ft 1in
Aspect ratio	11·1	4·95	2·1

Weights :

Structure, lb	2697
Power plant, lb	1455
Fuel and oil supply, lb	108
Airframe and equipment services, lb	378
Airframe equipment, lb	318
Furnishings, lb	67
Operators' service items, lb	307
Weight, less fuel and payload, lb	5330
Fuel and payload, lb	3270
All-up weight, lb	8600

Two prototypes are under construction and the first is expected to fly in mid-1961; production aircraft should be available in 1962. We are informed that much interest has already been evinced, particularly by military operators. It is hoped to reduce the cost of production aircraft by manufacturing much of the equipment in Great Britain—engines, for instance, may be built by Rolls-Royce, Ltd., under licence. Nevertheless, it is not considered out of the question for the SC-7 to be built by the Beech Aircraft Corporation, Wichita, Kansas, whose aircraft are distributed in this country by Short Brothers and Harland, Ltd., in conjunction with Aircraft Associates, Ltd.



A model of the "Skyvan," the first British aeroplane to have certificated turbo-charged engines

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(All the necessities in this detail are covered by a mechanism of elemental simplicity that allows the fire-door to fall open by gravity when a trigger is loaded by side pressure from the sole of the fireman's shoe and that allows the door to be closed by the shovel immediately after each "shot.")

Although every widely used variety of fire-door and, indeed, of every other cab-fitting can be criticised on one score or another, the practical effect is less than might be expected because human beings can get used to almost anything and eventually cease to complain. This may allow the responsible designer to forget the matter, but it still leaves an element of inefficiency in the operating conditions.

Some designs of locomotive have failed to come up to reasonable expectations simply because they had features that made them unnecessarily difficult to fire properly. A good fireman in a good humour could make them perform creditably, but most firemen are unable or unwilling to take special interest in counteracting the results of a defect in design and so the class of locomotive retains an indifferent reputation, no matter what other modifications may be made to it in the absence of recognition of the real fault.

Even with every good intention in the designer, the utility and convenience of any new assemblage of cab fittings seems impossible to predict and difficult to assess even after trial. Enginemen have often accustomed themselves to unnecessary awkwardness before any report about it has penetrated to anyone willing and able to alleviate it and, indeed, there can be widely different opinions about every aspect of footplate work. Some firemen, for example, will complain if the firehole deflector plate is not so long as it ought to be, while others will throw it overboard whatever its length.

The designer of British Railways standard cabs could never hope to suit every engineman, but a determined attempt was made to combine what seemed to those in authority to be the best of existing arrangements.

The mounting of the cab on the boiler of each tender engine instead of on the frame would seem to be sound practice, and it is probably wrong to blame it for the exceptional noise in B.R. cabs of this type.

General Design Policy

The abundance and low cost of labour in 1900 made it unnecessary to develop really economical designs and left designers free to comply with certain current conventions. An ideal at that time was to present a smooth exterior and to this end components of locomotives were concealed in spite of the resultant rise in cost of maintenance. Examination of sixty-year-old drawings shows almost incredible examples of this; a very remarkable case was the positioning of London and North Western injectors under the footplate in a narrow space between the ash-pan and the rear coupled axle. The reliability of the Crewe injector evidently inspired a faith that no modern design can equal.

In some other countries there was more enlightened thinking on the subject of accessibility, and when it spread here the resultant rational designs perturbed amateur admirers of the age of concealment and even some professionals suffered nameless fears.

There were a few attempts to ease the lot of those who did the most unpleasant regular jobs on steam locomotives, such as fire-dropping and smokebox emptying. There was evidently no economic necessity for this as very crude methods of fuelling and emptying locomotives are still in common use, but it is nevertheless possible that full scale mechanisation of locomotive shed work would have paid for itself in the past.

Only very limited use has been made here of special feed-water treatment[4] that has very markedly reduced locomotive boiler maintenance costs in France since 1939. Similarly, there are very few duplicates of the locomotive inspection chamber introduced in Britain during World War II. In this chamber, under a ventilated roof and over a pit, stands every locomotive for a few minutes on returning to the shed, while every part is strongly lit to facilitate discovery of such defects as loose or missing nuts.

The only general improvement in design to facilitate daily servicing has been the wider use of rocking-grates and self-emptying ash-pans since World War II than there was before, but even now they are uncommon outside their universal application in B.R. standard designs. The self-emptying smokebox, designed so that half-burned "char" is thrown from the chimney instead of accumulating in the box, has not won universal commendation in this country; it is not always possible to apply the self-cleaning principle without detrimental effect on the draught through the fire.

The "individual costing" procedure applied on the L.M.S. gave, probably for the first time, reasonably reliable figures for the running costs of locomotives and showed marked disparities between designs inherited from various constituent companies of the L.M.S. group. Information of the same sort was invaluable when the time came to design new British Railways standard classes after nationalisation in 1948. Although by this time each of the four groups had developed sound designs for the ordinary classes of railway haulage, it was deemed desirable, for non-technical reasons, not to adopt any of them but to draw up an entirely new set of designs with maximum interchangeability of components, just as Churchward did nearly a half-century earlier. As in his practice, every B.R. design had only two (outside) cylinders; in addition outside Walschaerts valve gear is a B.R. standard feature whereas in 1901 it had not been thoroughly tried out in America and so Churchward adopted Stephenson gear as was common there.

Sound reasons were produced to show why no British Railways locomotive should have multiple exhaust or more than two cylinders, or anything but piston valves, but old habits prevailed in the end to the extent of the building of a single three-cylinder "Pacific" with poppet valves and double chimney.

The last B.R. design, the class "9" 2–10–0 for freight service, has had occasional use on passenger trains, and with them has sometimes touched speeds up to 90 m.p.h. This has naturally suggested that here is the perfect all-purpose steam locomotive, but those in authority have frowned on speeds higher than 60 m.p.h. with these engines. Over the last century there have been repeated examples of high speeds by freight engines followed every time by the hint that the case for large

driving wheels was thereby disproved. What the enthusiast overlooks is the difference between an occasional sprint and a class of duty that demands comparable speed regularly. Greater wear and tear is to be expected with marked rise in rotational speeds of the driving wheels and this in itself would justify the practice of adopting the largest possible driving-wheel diameter when designing for high-speed service.

Streamlining of locomotives is a prestige feature that has been largely dropped. The Great Western was the first in Britain to try it and the first to discard it. It has been retained (apart from a detail) on the Gresley "Pacifics" to which it was applied in 1935-38 and which were used before 1940 on services with average speeds perhaps high enough to make its power-saving perceptible. On the L.M.S. and the Southern Region it has been abandoned, and so British practice shows that this particular idea of George Stephenson's is not in fact worth while.

Despite the general excellence of B.R. designs (and many others in wide use), no more steam locomotives are to be built for British Railways. It is not that the real running cost of steam locomotives need be significantly higher than that of any known alternative, but rather that they do not fit in well with the modern practice, following a long lead by the automobile industry, of designing machines so that they can be handled by people of poor physique and low mentality. The steam locomotive at its best demands of operating staff qualities higher than now suffice to produce a comfortable living in other industrial spheres, and so it sets its owners an exceptionally severe problem in recruiting labour of adequate quality in adequate quantity.

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Light Aircraft for Freighting

THERE has been announced by the Light Aircraft Division of Short Brothers and Harland, Ltd., a freighter for 3000 lb payload with the ease of loading and facility for air-dropping that are now expected with heavy military transports. The SC-7 "Skyvan," which is designed around a highly functional box-shaped fuselage, traces its ancestry from the Miles "Aerovan"; it will be recalled that the firm of Hurel-Dubois and Miles (Aviation), Ltd., demonstrated at the S.B.A.C. Exhibition in 1957 the HDM-105, an "Aerovan" with a high aspect ratio wing and lifting bracing on Hurel-Dubois principles, and projected a larger version with two horizontally opposed engines, the HDM-106 "Caravan." It proved impossible to finance this project, and concept and design were sold to Short Brothers and Harland, Ltd. The latter considers that 600 yard fields are so widely available that the extra expense of S.T.O.L. performance would not enhance the market prospects for the machine (the Miles project was visualised as having application in such adverse environments as colonial warfare in Africa) and so the aspect ratio has dropped to 11·1, the plan form remaining rectangular, and a laminar flow section been adopted; the increase in induced and reduction in profile drag have raised the minimum power speed roughly 100 per cent, so the flaps-up stall, power on, is now 55 knots and the final approach speed 80 knots. It should perhaps be interpolated that the attainment of laminar flow is not critical to the performance, the section being chosen rather to yield a wide range of C_L at low C_D—it is N.A.C.A. 63_4–614—rather than in the expectation of delaying transition right across the span, and, in fact, the skin panels are butt-jointed with external cover straps. The new aircraft has been designed for equal take-off and landing distances of 577 yards at 5000ft and I.S.A. +30 deg. Cent., the balanced field length for air-line operation in this case being 1066 yards. Our illustration shows that the inward-hinging door necessary for air-dropping gives the fuselage very much the shape of an aerofoil, and the stability and control problems centred on the pitching moments induced by the fuselage; it is anticipated that control effectiveness will not circumscribe the flight envelope, to the extent that there should be 8 deg. of elevator travel still available at the stall, and that the c.g. range will allow a tolerance of nearly 4ft on the c.g. of a 3000 lb load.

While the machine may appear primitive, the design avails itself of advanced techniques where they are appropriate. The engines are Continental GTSIO-520 flat sixes with direct fuel injection and a rated altitude of 10,000ft, so that operation is practical virtually anywhere provided airframe icing beyond the capability of the chemical systems on propellers and aerofoils is not encountered. The accurate contours demanded for laminar flow are obtained by extensive use of bonding, the skin panels being composed of a corrugated sheet with the "crests" flat and bonded with "Redux" to a smooth outer skin—the result may be likened to a Junkers W.34 or Ford Trimotor panel with an aerodynamic surface added. The ribs or formers pick up the panel at the "crest" and are riveted through. The panels are bonded in an autoclave, but for repair in the field it is intended that the outer surface should have a patch attached by cold bonding and the inner, stabilising sheet be mended with angles attached by blind riveting. This construction explains the predominance of surfaces with straight parallel generators, the corrugated sheet running from end to end of, say, one wing, and the outer skin running at right angles and being graded in thickness according to the load. This construction is expected, because of the absence of stress-raisers at fastenings, to be highly fatigue resistant, since the aircraft will be sold with a guaranteed safe life.

The fuselage has an available volume 6ft 6in square by 16ft long, the floor being strong enough for 150 lb per square foot anywhere and 300 lb per square foot in the centre; it is provided with combined lashing points and seat attachments. This space is large enough to accept the biggest vehicle within the 3000 lb maximum payload, a Citroen "Safari." So that the full width of the hold can be occupied by freight, doors at floor level open outward to give access to the lashings. The floor is at less than truck-bed height, 2ft 2in, and jacks are provided under the rear sill to prevent its height changing with load. The fuselage can accommodate up to fifteen passenger seats (with a toilet and pantry over the rear door), twelve stretcher cases, twelve armed parachute soldiers, or crop-dusting or -spraying apparatus. A roller conveyor on the floor will allow loads up to 5ft high and about 2800 lb in weight to be parachuted down.

The flight deck is designed for a crew of one, although dual control can be provided. Particularly comprehensive is the radio equipment, which is allotted the space between the seats normally occupied by the engine controls, which on this machine are in the roof conveniently near to the engines. The radio equipment is to one of two ordained standards, v.h.f. communications and v.o.r. navigation or h.f. communications and a.d.f. navigation; the actual equipment has been selected from the best available and is predominantly of United States origin.

The aircraft is sufficiently powerful to attain the B.C.A.R. second sector climb gradient of 2·4 per cent at 5000ft and I.S.A. +30 per cent with 200 lb to spare, and has been stressed for an all-up weight of 9000 lb, so it is expected to evolve into a 2 (short) ton freighter.

Leading Particulars

Overall dimensions

Length	38ft 11in
Span	64ft 1in
Height	13ft 10·3in

Fuselage

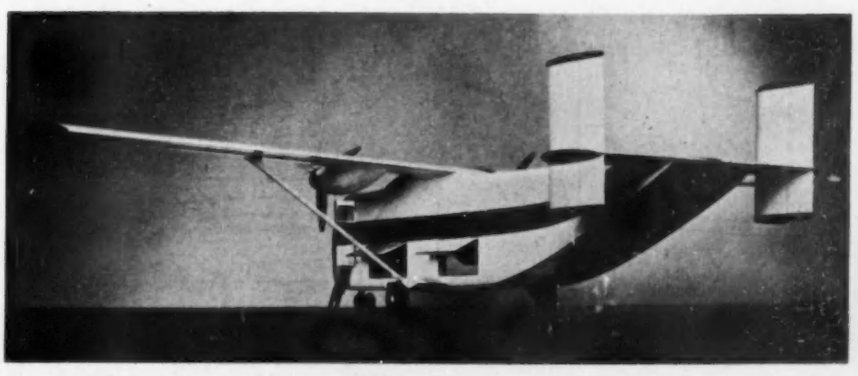
Gross internal volume	1195 cubic feet
Crew compartment volume	132 cubic feet
Main hold volume	680 cubic feet
Main hold floor area	104 square feet

Aerofoils :	Wing	Tailplane	Fins
Gross area	373 sq. ft	83 sq. ft	79 sq. ft
Span	64ft 1in	20ft 3in	9ft 1in
Aspect ratio	11·1	4·95	2·1

Weights :

Structure, lb	2697
Power plant, lb	1455
Fuel and oil supply, lb	108
Airframe and equipment services, lb	378
Airframe equipment, lb	318
Furnishings, lb	67
Operators' service items, lb	307
Weight, less fuel and payload, lb	5330
Fuel and payload, lb	3270
All-up weight, lb	8600

Two prototypes are under construction and the first is expected to fly in mid-1961; production aircraft should be available in 1962. We are informed that much interest has already been evinced, particularly by military operators. It is hoped to reduce the cost of production aircraft by manufacturing much of the equipment in Great Britain—engines, for instance, may be built by Rolls-Royce, Ltd., under licence. Nevertheless, it is not considered out of the question for the SC-7 to be built by the Beech Aircraft Corporation, Wichita, Kansas, whose aircraft are distributed in this country by Short Brothers and Harland, Ltd., in conjunction with Aircraft Associates, Ltd.



A model of the "Skyvan," the first British aeroplane to have certificated turbo-charged engines

SHORTER REPORTS

Mobile Screening and Stockpiling Conveyor

WE illustrate a mobile elevating, screening and stocking plant recently demonstrated before senior engineers of the National Coal Board by the designers, Michael and Partners, Ltd., 99, Saltergate, Chesterfield.

The machine, known as a "Loadascreen," which was made by Frederick Parker and Co., Ltd., Leicester, for the designers, was shown in use as a stockpiler. Coal discharged into the apron hopper of the machine at ground level is raised by a 30in wide belt, running on 50ft centres, and deposited on to a 48in by 96in double deck vibrating screen. In the machine illustrated, the top screening cloth has been replaced by a solid plate so that it serves as a vibratory conveyor. From this plate the screened coal passes down a fish-tailed chute to the stockpile.

Mobile elevating, screening and stockpiling machine in operation

The machine enables coal to be stockpiled to a height of 18ft with negligible degradation. Its apron hopper is fitted with rubber flaps at the back to seal against lorry sides and bottoms, and adjustable drop fingers at the front to control the flow of the coal up the conveyor. The coal falls less than 9in from the conveyor head to the vibrating screen, and a strip of belting slows down the material as it passes over the screen.

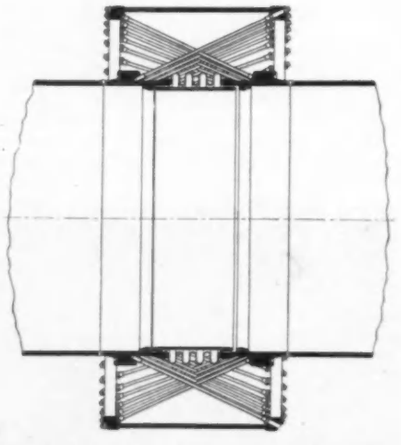
The boom elevation, the discharge chute angle, and the rear castor wheels of the machine are hydraulically controlled from a cab which, in the model to be placed on the market, will be totally enclosed by sheet metal walls with transparent plastic opening windows fore and aft. The loader is mounted on a pair of swivelling road wheels so that from one position of the hopper it can stockpile in an arc with a radius of 64ft, laying down a stock of coal 120ft wide. The main drive is by a 15 h.p. squirrel cage, totally-enclosed and weatherproof, electric motor and the hydraulics are operated by a 7½ h.p. motor; alternatively the machine can be powered by diesel engines.

In addition to stockpiling duties the "Loadascreen" can be used for loading road or rail vehicles, when a three-way discharge chute is fitted to the vibrating screen so that three grades of coal can be loaded into three vehicles at one time.

[Reply Card No. E4001]

Expansion Joint for High-Pressure Ducting

PROVISION has to be made for considerable thermal expansion in the ducting conveying the coolant gas from nuclear reactors to heat exchangers. Operating pressures and conditions are such that telescopic type expansion joints cannot be used, and the usual solution is to provide in each leg of the ducting three flexible pin joints, and to accommodate the expansion by angular deflections. The expansion joints must therefore be capable of transmitting the axial duct thrusts, amounting in some cases to over 1,000,000 lb, and at the same time allowance must be made for a predetermined amount of angular deformation. A more or less conventional convolution type bellows can be used as a gas seal, but the restraint mechanism transmitting the axial thrust presents a difficult engineering problem. Existing solutions fall, broadly speaking, into two categories. One uses what amounts to a pair of hinge pins, placed on both sides of the duct, the other a flexible tongue inside the duct; some designs combine both. In both types of design there are difficulties.



Expansion joint for nuclear reactor coolant or other high-pressure, high-temperature ducting

To overcome the problems set by existing designs, Richardsons, Westgarth and Co., Ltd., Wallsend, Northumberland, has developed a new type of restraint. It will be used for the first time in the Trawsfynydd nuclear power station, North Wales, at present being built by Atomic Power Constructions, Ltd., of which Richardsons, Westgarth is one of the founder member companies.

As shown in the accompanying drawing, the restraint consists of a multiplicity of high tensile bars, arranged in two groups into two frusto-conical assemblies, and spaced uniformly around the periphery of the duct, to transmit the axial forces entirely uniformly. In the axial direction the joint behaves as a stiff connection, but it can deform angularly by transverse bending of the bars. Deformation of the restraint is achieved by pure elastic deformation of the restraint bars, so the forces involved are both accurately predictable and not variable in time. Furthermore, the complete rotational symmetry of the restraint makes it equally flexible in any direction.

A wide range of working deflections and restoring moments can be accommodated by varying the basic dimensions of the restraint, the number and size of the tie bars, and the cone angle. In the restraint shown in the accompanying drawing the bars have actually been overcrossed, giving small overall length.

A centring device connecting the two duct stub ends ensures that no torque loading can be applied to the convolutions and equalises the deflections of the two sets of bars under conditions of steeply changing bending moment along the duct. The shear force accompanying such a change of bending moment is taken entirely by this device, leaving the bellows free of additional loading. A further advantage of the design is that the accurately calculable stress system allows a close approach to an ideal shape in the tension bars.

The bars are cold swaged to a profile approximating constant stress distribution along their length, and selected numbers undergo individual fatigue checks on a specially built rig. Apart from the bellows convolutions, the tension bars are the only components which are subjected to appreciable stresses. This makes it possible to use for these components steels of the highest quality, and to apply the most stringent manufacturing controls.

[Reply Card No. E4002]

Radio Convention on Space Research

THE subject of next year's British Institution of Radio Engineers Convention will be "Communications and Space Research." In announcing this decision, the Institution's Council has in mind the need for an open discussion on the vast amount of work now being carried out in this country and elsewhere in developing space communication techniques. Recent articles in the Institution's journal have referred to proposals for using satellites for relaying radio and television signals, and this will form the subject of an important session of the convention. Associated techniques such as the role of electronics in the guidance and control of rockets and space vehicles, radio astronomy and radio measurements in the ionosphere will also be discussed. In accordance with the custom of the institution, the convention will be held during the summer months at a British university and will be residential. A further announcement will be made shortly regarding date and place.

New London Office Building

THE new London headquarters offices of the English Electric Group of Companies, occupying the site in the Strand of the former Gaiety Theatre, have now been completed and will be opened officially in the autumn. Two wings extend from this building, along the Strand and Aldwych respectively, and join with the former Marconi House (now known as the Marconi wing) to enclose a central courtyard, the whole block being known as English Electric House. Two 18ft bronze figures by Sir Charles Wheeler above the main entrance doors, seen in the accompanying illustration, represent "Power" and "Speed." Behind the outer stainless steel doors are plate glass doors with photocell control of opening and shutting which lead to a large main entrance hall, an exhibition hall, and ground floor offices. Lighting is graded from 15 lumens per square foot in the entrance to 75 lumens per square foot in the exhibition hall, where the hot cathode fluorescent tubes are mounted above a diffusing ceiling. A clearance of approximately 1ft 8in between the ceiling and the tubes was available in this installation and results in uniform brightness over the whole ceiling.

The building, with the Marconi wing, provides a total floor area of some 200,000 square feet, and from lower basement to roof contains fourteen floors. The height of the building from pavement level to the observation room roof on the tenth floor is 118ft. On the roof is a 35ft mast on which all types of aerial can be mounted. The building is faced in Portland stone treated with silicones to eliminate cleaning costs, and the window casements throughout are in aluminium alloy. For this reason the bronze figures on the entrance facade have been covered in aluminium leaf, and the restored figure of the Gaiety "Angel" from the dome of the theatre, now installed in the courtyard garden, is also silvered. Double casements are provided up to fourth floor level to reduce traffic noise.

Air-conditioning is installed up to the fourth floor. This is supplied by three plants serving respectively the Aldwych and the Strand sides of the building and the exhibition hall. Two air filters are provided for each plant to remove the coarser and finer particles of dust respectively. In the primary filters the incoming air is passed through a blanket of glass fibre material which is wound from one spool to another across the air passage under the control of a timing device. Secondary filters are electrostatic; incoming air is passed through a positive field, which charges the dust particles. A later section of the filter is charged to the opposite polarity and the particles are deposited. Refrigerating plant with a total of 130 h.p. has been installed to provide chilled water for the air cooler batteries. The building is heated by two 1200kVA, 11kV electrode boilers operating under the control of a time switch to take advantage of an off-peak tariff. The solenoid-operated circuit-breakers controlling each boiler are supplied from the battery which feeds the automatic emergency lighting system in plant rooms, corridors and general circulation spaces. Incoming supplies to all electrical services other than the high-voltage supply to the electrode boilers are controlled from a cubicle switchboard.

Four Otis lifts, operating under an automatic programme control which changes at different parts of the day, go from basement level to the eight floor. Each is capable of carrying eight persons at a speed of 500ft per minute. The lifts are driven by gearless motors with motor-generator variable voltage control giving a top speed of approximately 300 r.p.m. Garage accommodation is provided in the basement of the building. The access ramp has floor-heating to prevent ice formation. Delivery vans are turned on a turntable after unloading to avoid backing out into the traffic stream. Light signals at both ends of the ramp are under fixed-time control modified by vehicle-operated detectors which override the time cycle and allow another vehicle to approach after a preceding one has entered its berth.

The building work has been carried out by Taylor Woodrow Construction, Ltd., and the consulting engineers were Oscar Faber and Partners.

Main entrance façade and wings (Marconi wing on right) of English Electric House. The roof mast supports radar aerials for demonstrating equipment

Semiconductor Devices

SIX new series of transistors, controlled rectifiers and diodes are announced by Texas Instruments, Ltd., Dallas Road, Bedford. They include diffused silicon diodes specifically for industrial users. This series (15101) consists of four diodes with an average forward current rating of 750mA at 50 deg. Cent., and peak inverse voltage ratings between 200V and 800V. All four devices have a surge current rating of 40A for 10 microseconds. For power switching the company has introduced five p-n-p-n devices (series 15610) for peak inverse voltages between 50V and 400V and an average rectified forward current of 1A at 65 deg. Cent. The maximum gate current required to turn on is 20mA (typical 5mA), and a forward current of 5mA will keep the device on in a typical unit. Typical applications are found in the replacement of magnetic amplifiers and thyratrons.

Among the new transistors are the 2N715 and 2N716 mesa v.h.f. devices for use as oscillators and amplifiers up to 200 Mc/s. The 2N715 gives an output of at least 200mW as an oscillator at 70 Mc/s and more than 300mW as an amplifier at the same frequency. Minimum figures for the 2N716 at the same frequency are approximately twice those of the 2N715. The mesa form is also used in the 2G301 series medium speed switching transistors for computer and similar circuitry and the 2N696 series high speed, medium power switching transistors introduced to handle the increasing frequencies required for core-driving applications. Other introductions are silicon grown junction transistors (Series 2S701) for industrial applications where a low collector leakage current and high cut-off frequency are required.

[Reply Card No. E4012]

Electrical Engineers Exhibition

THE tenth Electrical Engineers Exhibition at Earls Court, London, will open on March 21, 1961, for five days. Provisional space bookings, increased this year, show that over 460 British electrical manufacturers will be showing their latest developments. Requests for space have been received from over thirty new exhibitors.

The Association of Supervising Electrical Engineers will again present awards for outstanding new products in the industrial and domestic fields, exhibited for the first time. In view of the current programmes of railway electrification, and improvements in road and telephone systems, signalling and communications will be the special feature of the 1961 show. It is intended to provide a display of many of the latest developments in telephones, cables and associated equipment, road and rail signalling equipment, lighting and controls, and various aspects of railway electrification.

Purer Metals

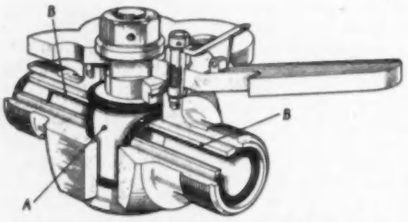
IT is announced by Johnson, Matthey and Co., Ltd., that the firm is now producing very pure arsenic, antimony, tellurium and bismuth on a commercial scale. By means of newly developed techniques, arsenic is being produced with an impurity level of the order of 1 p.p.m., detected by use of present known and accepted spectrographic methods: the element is in the form of crystalline lumps and is packed in vacuum-sealed glass tubes. Antimony, with a maximum metallic impurity content of 5 p.p.m., and bismuth, with a maximum level of metallic impurities of 10 p.p.m., are being produced in ingot form. Zone-refined tellurium, with a metallic impurity content of the order of 1 p.p.m. is also available in bulk, in the forms of ingot or grain. These four high purity metals find growing application in the form of inter-metallic compounds. For example, gallium arsenide is used in the production of special diodes and transistors (see page 412), indium antimonide and indium arsenide are used for magneto-sensitive devices, and bismuth telluride is used in Peltier cooling units.

[Reply Card No. E4014]

SHORTER REPORTS *(Continued)*

Parallel Plug Rotary Valves

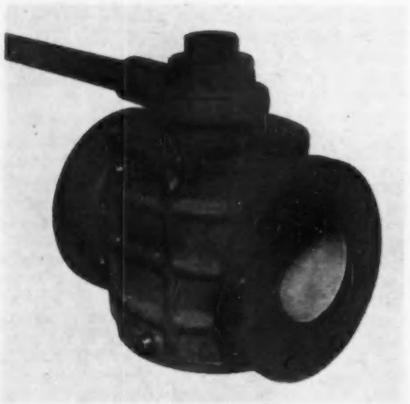
A NEW design of parallel plug rotary valve which is of very simple construction and takes full advantage of the effective sealing properties of "O" rings has been developed by Peckett and Sons, Ltd., St. George, Bristol. For high-pressure applications in oil, water or air systems up to 3500 lb per square inch, valves in forged steel and up to 1¼in nominal size are available. The range also includes gunmetal valves up to 2in bore for working pressures up to 500 lb per square inch, and cast iron valves from 3in to 8in bore for working pressures up to 250 lb per square inch. Most fluids at temperatures not



Construction of a high-pressure parallel plug rotary valve for working pressures up to 3500 lb per square inch

exceeding 400 deg. Fah. can be handled with these valves, the only limitations on which are stated to be those set by the "O" ring materials available at present.

The drawing we reproduce shows the construction of a high pressure valve, the principle of operation of which is generally similar to that of other valves in the range. The rotary cylindrical plug *A* in the valve body has an annular clearance which is sufficient to receive a standard "O" sealing ring. Two bored spigots *B,B* are fitted into the cross bores on each side of the valve with their ends projecting into the annular clearance. The inner end faces of these spigots are machined to the same radius as the plug and embrace it with a normal working clearance. Over the projecting inner ends of the spigots there are located bore-sealing "O" rings which, being trapped in the annulus,



Cast iron parallel plug full bore rotary valve for working pressures up to 250 lb per square inch

are constrained to take up a shape curved in two planes. A collar formed at the bottom of the plug and a free collar at the top, held by a nut, locate and secure the plug in the body. Gland sealing rings against these top and bottom collars prevent external leakage past the plug. The top collar also carries the handle used to turn the plug. The bores through the spigots and the plug provide a smooth uninterrupted passage for fluid.

In an installation, when pressure is applied from one side of the valve the bore-sealing ring on the spigot on that side expands circumferentially, and in so doing its cross section is slightly reduced. This reduction permits leakage of fluid or gas into the annular space between the plug and body. This pressure builds up and forces the other bore-sealing ring at the outlet side of the valve on to its spigot and makes a pressure-tight seal. The pressure in the annular chamber also forces the top and bottom sealing rings against their collars to ensure pressure tight joints. By the fitting of sealing rings to both spigots the valve seal is effective for both directions of flow in a system and side thrust on the plug is balanced. When these valves are required for use in a vacuum system the top and bottom collars are grooved to trap the sealing rings and prevent them being drawn inwards.

It is claimed that this design of valve is bubble-tight under both pressure and vacuum and requires no lubrication except in special cases. When maintenance is necessary four new sealing rings can be fitted in a few minutes to restore full working efficiency without need for removing a valve from the line.

[Reply Card No. E4021]

High-Speed Coal Shipping

OPERATION of two new coal shipping plants installed by British Transport Docks at Immingham, Lincolnshire, is initiated by push button. Once set in motion, the plants work automatically until stopped by an operator, and all movements in each plant are overlapped, so that a continuous flow of coal from railway wagons to the ship is maintained.

Designed and built to the requirements of British Transport Docks by Mitchell Engineering Ltd., Peterborough, the two plants are installed 400ft apart on the south quay of the docks. Both plants can handle fifty-five wagons of coal an hour, the throughput varying with the size of the wagons, which range from 10 to 24½ tons capacity. In a recent trial one plant shipped 17,500 tons of washed small coal from small capacity rail wagons aboard a bulk cargo vessel in 29½ hours, at an average rate of 600 tons an hour. Only two operators are needed; one controls the wagon haulage and tippler plants, and the other is responsible for all other operations. The operators are in telephone communication with each other, and with the wagon marshalling staff.

Wagons gravitate from the marshalling sidings to the foot of an incline leading to the tippler and a haulage mule engages automatically with the coupling of the first wagon to haul it up to the tippler. Just before it reaches the tippler, control of the wagon is taken over by the wagon placer, which, engaging the rear buffers, takes charge and pushes the wagon on to the tippler cradle, so disengaging the mule. Both mule and placer return to their starting points, the placer to wait for the next wagon, and the mule to bring it up the incline. Immediately the placer is away from the wagon, the tippler starts, elevates the wagon, and tips the coal into a hopper. A brief pause follows to allow the wagon to empty completely, then the tippler returns the wagon to the track. By this time the next full wagon has arrived at the top of the incline, and it pushes the empty one off the cradle to an incline leading to a kick-back and catch points. From this point the empty wagon gravitates to the sidings.

Coal is discharged from the tippler hopper by an apron plate feeder to a belt conveyor leading to the adjustable loading boom extending over the ship's hold. This boom is telescopic and vertically adjustable; in addition the whole tower structure is mounted on a radial rail track. By a combination of the various movements possible, any part of the ship's hold can be reached, at any stage in the loading procedure.

Although loading is normally under automatic control once the plant has been set in motion, there is provision for each section to be run individually, under manual control, for testing purposes. In addition, the conveyor and feeder can be run at half speed when required, for filling a ship's bunkers, or for topping-up holds.

[Reply Card No. E4022]

Chemical De-Emulsification Agent

WHEN contaminated with sea-water oil fuel is liable to form stable emulsions which are the source of many troubles, including corrosion of tubes and slagging of refractories. The stability of the emulsions varies with the source of the oil fuel, but stable emulsions can be made with practically any furnace oil fuel. It is inevitable that the sea-water used as ballast in dual-purpose fuel tanks becomes contaminated with oil fuel which must be separated before the water is discharged, since it is an offence to discharge contaminated ballast water in harbour. British ships are required to use an oily water separator when de-ballasting, but the oil collected in the separators and drawn into the sludge tank cannot be used as fuel since it contains up to 30 per cent sea-water by weight. At the request of the Admiralty, the Department of Scientific and Industrial Research investigated the problem and after examination of methods of de-emulsification decided to "tailor-make" a molecule for this purpose. With the co-operation of Glovers Chemicals, Ltd., an efficient molecular structure was developed and has been patented under the name of "Fomescol." This chemical agent enables the oil to be stripped of its sea-water content and the dry oil recovered to be used as fuel, while the cost involved is low since more than 80 per cent of the agent can be recovered for re-use.

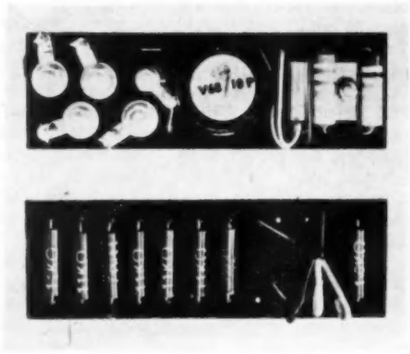
[Reply Card No. E4023]

Oil Production in Iraq

A REPORT issued by the Iraq, Basrah and Mosul Petroleum Companies, Ltd., indicates that they are currently involved in a £100 million capital programme to expand Iraq's production capacity. Last year production from the three concession areas totalled 40,897,676 long tons, an increase of 7 per cent over 1958, of which I.P.C. produced 27,330,109 tons, B.P.C. produced 12,297,162 tons and M.P.C. produced 1,270,405 tons. Exports amounted to 38,803,000 tons of which 81½ per cent went to Western Europe, 11½ per cent went to the Far East, while the U.S.A. took ·4 per cent. During 1959 extensive geological and geophysical surveying was carried out, and the total footage drilled amounted to 138,459 against 88,525 in 1958. Altogether 23 wells were completed, compared with 14 in the previous year, and of these 11 were completed as producers, 2 as observation wells, 4 as water injection wells, while the remaining 6 proved to be dry. To handle the increase in production, the report notes the construction of 2 degassing stations. In 1957 work started on laying loops to parallel the 30in pipeline laid in 1952 and by the end of 1959, 306 miles of new sections from the Iraq border to the Mediterranean had been completed, while in Iraq 249 miles of loops were in hand from Kirkuk to the frontier. When complete the northern pipeline system will have a capacity of 35,000,000 tons per year. In the south, a new terminal is under construction south of Fao, involving the laying of two 32in pipelines to link Fao and the new deep water terminal, which when complete will have a capacity of 22,000,000 tons per annum.

Miniature Logic Units

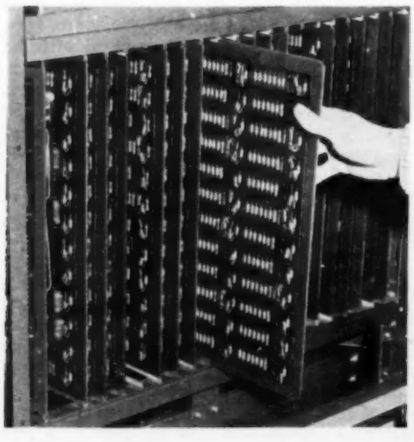
FOUR standard elements known as " Minilogs " enable logical circuits required for control, telemetry and other functions to be planned and assembled with a flexibility which allows virtually unlimited application. These units, with their associated assembly boards and chassis, are products of Panellit, Ltd., Elstree Way, Borehamwood, Herts. The basic element comprises a group of resistors and a transistor forming a circuit which operates as a gate with up to six inputs. Inversion takes place in the circuit, the output with all inputs present and positive being −10V. Usually the inputs can be arranged so that the gate operates either as an " and " or as an " or " gate, although in some circumstances



Power element (above) and logic element (below) of miniature logic system

two elements may be required for the " or " function. A similar logic unit with the addition of an emitter follower is used as a driver for up to fifty elements. Final outputs are taken from power transistor elements of similar form which will deliver 50W. " Minilogs " will perform all logical functions, including storage (obtained by connecting two elements in a flip-flop circuit) and monitoring of inputs to detect coincidence, for which four elements are used. The system is basically asynchronous in operation, no timing pulses being required, although the " Minilogs " can be used to generate timing waveforms when needed for purposes such as telemetry.

The form of the basic logic and power elements is seen in one of the accompanying illustrations.



Inserting an assembly of logic units into a chassis

In the second illustration elements are seen mounted on insulating boards which slide into chassis designed for mounting in standard 19in racking. The leads from the " Minilog " components pass through holes in the boards for connection to wiring on the other side. Interconnections between boards are made through plugs and sockets which engage automatically when the panels are slid into place.

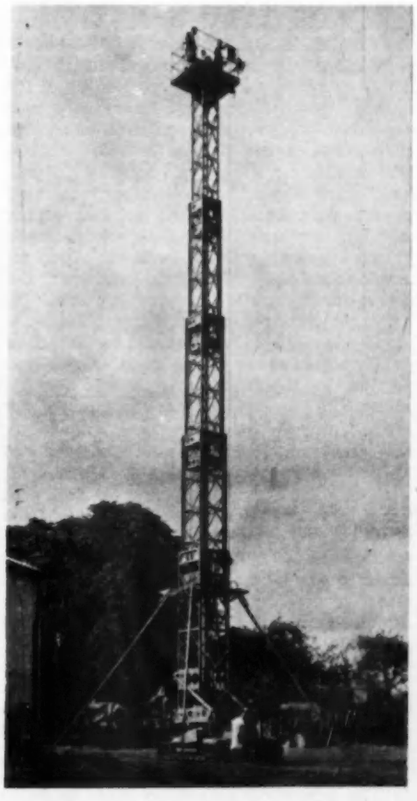
Among applications of " Minilogs " may be mentioned the drive of an electric typewriter by direct connection of the power elements to the solenoids operating the type heads. A further example of direct drive was the illumination of edge-lit visual indicators in response to signals from the " ELLA " computer when showing election results on B.B.C. television. Schemes under development include one for conveyor control to enable a single conveyor to feed a variety of articles to different machines in response to demand signals initiated by hopper switches. The scheme would enable the conveyor to be attended by one unskilled operator who would be required only to attach delivery buckets to the belt in accordance with requirements shown by indicator lamps on a panel. Development is in hand of circuits for telemetry in various large-scale industries, data logging and the application of the units for analogue-to-digital conversion. " Minilog " elements form the whole of the logical circuitry in the Elliott " Optimat " process control system described in our June 3 issue.

[Reply Card No. E4031]

Mobile Mine Tower

WE illustrate one of the four towers being supplied to the U.S.S.R. by F. Taylor and Sons (Manchester), Ltd., Salford, Lancs, as part of the £250,000 order for mobile mining equipment secured last year. These machines will be used in conjunction with the mobile drilling rigs illustrated and described in our issue of May 13, 1960. They are intended for roof scaling, bolting and inspection duties with mine roofs up to 90ft in height.

Each machine is essentially a crawler tractor on which there is a sub-frame carrying a five-section telescopic tower with a working platform designed for a safe working load of 660 lb. The tower is extended by 14ft stroke double-acting hydraulic cylinders attached to the two lowermost sections and imparting simultaneous movement to the other three sections through a system of wire ropes and pulleys. The maximum height of 81ft is attained in just under three minutes. When the tower is retracted for travelling purposes it is pivoted through 90 deg. to rest on the sub-frame of the chassis. In this travelling position the equipment has an overall height of 11ft 3in.



Mobile mine roof scaling and inspection tower fully extended to a height of 81ft

At a working site, when the telescoped tower has been raised to its vertical position by twin hydraulic rams its outer main base section is locked by tapered pins to the base-frame. The crawler chassis is then slewed on its tracks to level the tower base-frame within certain limits laterally with reference to an indicator. Twin screw jacks connecting the base frame to the chassis are then operated to level the base longitudinally with reference to a second indicator. Four support or stabilising legs hinged to the top corners of the outer tower section are then swung out and extended by hydraulic rams to embed their spiked feet into the ground. When these legs have been extended to stabilise the tower the oil circuits of their rams are locked by pilot-operated non-return valves. With the equipment thus levelled and securely stabilised, the tower can be extended as required under push-button control from the platform.

A hydraulic pump driven by a 7½ h.p. motor supplies pressure fluid for the system, and restrictor valves incorporated in the circuits come into operation should the piping be damaged to lower the tower at a slow, safe speed. The tractor chassis is propelled by a 40 h.p. motor and power for the traction and pump motors is supplied by a trailing cable through a 100A plug and socket. The crawler tracks are inter-connected through a single rocking beam attached to the centre of the chassis, which is built up of cross braced steel channel members. This form of suspension permits limited articulation of the tracks when the machine is travelling over rough ground. The machine can negotiate gradients of 1 in 10 and has a top travelling speed of 1·05 m.p.h.; It weighs some 12 tons and the track pressure is limited to 1·4 lb per square inch.

[Reply Card No. E4032]

Launches and Trial Trips

WILLIAM WHEELWRIGHT, oil tanker ; built at Belfast by Harland and Wolff, Ltd., for the Pacific Steam Navigation Company ; length between perpendiculars 715ft, breadth moulded 98ft, depth moulded 52ft 6in, deadweight 47,200 tons ; thirty-six cargo oil tanks, one main cargo pump room ; two 740kW turbine-driven alternators, one 100kW diesel-driven alternator ; one set of double reduction geared turbines, 16,000 s.h.p. in service; two Babcock and Wilcox " Selectable Superheat " boilers supply steam at 600 lb per square inch and 900 deg. Fah. Trial July 4.

SKUA, light vessel ; built by Philip and Son, Ltd., for The Commissioners of Irish Lights ; length overall 136ft 5in, breadth 25ft, depth moulded 15ft ; 1¼in " Tayco " cable and one 4-ton stockless anchor ; lantern with 10 miles range; machinery includes two 4½kW and two 9kW diesel-driven generators, two diesel-driven air compressors. Trial, July 8.

BRITISH CURLEW, oil tanker ; built by Alexander Stephen and Sons, Ltd., for the B.P. Tanker Company, Ltd. ; length between perpendiculars 495ft, breadth moulded 69ft, depth moulded 37ft, deadweight 14,000 tons on 27ft 6in service draught or 15,500 tons on 29ft 4½in summer draught ; service speed 14½ knots ; twenty-seven cargo oil tanks, two main cargo pump rooms, four 500 tons per hour cargo pumps ; Stephen-Sulzer 7 RSAD 76 single-acting, two-stroke, turbo-charged diesel engine, 8750 maximum b.h.p. at 115 r.p.m., 7750 service b.h.p. Trial, June 20.

CLEVELAND, cargo ship ; built by the Chantiers et Ateliers de Provence for the Compagnie Generale Transatlantique ; length between perpendiculars 423ft 2½in, breadth moulded 62ft 5in, depth 36ft 5in, draught loaded 23ft 8in, deadweight 7500 tons, service speed 16 knots ; five holds, three bipod masts, one 30-ton, fourteen 5-ton and 10-ton derricks; supercharged Doxford four-cylinder oil engine, 7000 b.h.p. at 118 r.p.m. Trial, July 4.

LA SIERRA, cargo ship ; built by the Forges et Chantiers de la Mediterranée (La Seyne) for Buries Markes, Ltd. ; length between perpendiculars 437ft 6½in, breadth moulded 61ft, depth to shelter deck 40ft 6in, draught 27ft (open shelter), 30ft 6½in (closed shelter), trial speed 14·25 knots, deadweight 13,700 tons ; ten electric winches, three 220kW diesel-driven generators. Trial, July 1.

INDUSTRIAL NEWS

Wages and Hours

Changes in rates of wages and hours of work reported to the Ministry of Labour as having come into operation in the United Kingdom during July are estimated to have resulted in about 631,000 workpeople receiving an aggregate increase of approximately £191,000 in their full-time weekly rates of wages, whilst 256,000 workpeople had their normal weekly hours reduced by an average of two hours. The latest statistics issued by the Ministry show that some of the principal increases in rates of wages affected apprentices and young workers in the shipbuilding and shiprepairing industry, where increases ranged generally from 4s. to 16s. a week according to year of apprenticeship or age, and for apprentices, youths and boys in the engineering and allied industries, where increases ranged from 3s. 10d. to 17s. Revised pay scales have been authorised for Post Office engineering, motor transport and supplies grades, consequential increases having retrospective effect to March 1, 1959.

The Ministry of Labour says that of the total increase of £191,000 about £112,000 resulted from direct negotiations between employers and trade unions ; £62,000 from orders made under Wages Councils Acts ; £11,000 from arrangements made by Joint Industrial Councils or other joint standing bodies ; £4,000 from the operation of sliding scales based on the official index of retail prices ; and the remainder from arbitration awards.

In the iron, steel and non-ferrous scrap industry, the Ministry reports, agreement has been concluded during July for a reduction in normal weekly hours from forty-four to forty-two, effective from October 3, and for manual workers employed in local authorities' services in Scotland normal weekly hours will be reduced from forty-four to forty-two with effect from October 31.

Overseas Trade

Final figures issued by the Board of Trade for United Kingdom trade in July show that exports were valued at £274,800,000, imports at £381,400,000, and re-exports at £10,900,000. The figures for July seem to confirm, the Board of Trade states, the change to a downward trend in exports. In the three months May to July exports of United Kingdom products were, seasonally adjusted, 5 per cent less in value than in the three months February to April, and the fall cannot be attributed to exports to any particular area or of any particular group of products. Imports, after adjustment to eliminate normal seasonal variation, were 2½ per cent more in value in May to July than in the period February to April, the increase being wholly in manufactured goods. The average rate of exports in the first seven months of this year has been 6½ per cent above the average for last year, whilst the rate of imports has been 13 per cent higher.

Exports of engineering products in the last three months were only 3 per cent more than a year earlier, compared with a 14 per cent increase on a year earlier in the first four months of 1960. The fall could not be attributed to seasonable factors, states the Board. Exports of commercial vehicles were higher by 14 per cent in the last three months than a year earlier, and exports of scientific instruments were 10 per cent more in value than a year ago. One of the most marked falls since the opening months of this year, the Board of Trade statement shows, was in cars, this being mainly due to the sharp fall in exports to the United States. There were also substantial falls in the export of machinery, both electrical and non-electrical, exports of electrical machinery, apparatus and appliances being 4 per cent less in the last three months than a year earlier. Exports of boilers and boiler-house plant, pumps, mechanical handling plant and miscellaneous industrial machinery were less than a year ago, and also at a lower rate than in the first four months of this year. Exports of tractors were at a substantially lower rate than earlier in the year and showed an increase of only 20 per cent on a year earlier, compared with an increase of over 50 per cent on a year earlier in the first four months of the year. Although the export of machine tools in the first three months of this year was 25 per cent higher than a year earlier, the sharp increase showed signs of slackening when compared with the first four months of 1960, the statement points out. The fall in exports of electrical goods below the level of a year earlier was due to substantial falls in generators and motors, transformers, switchgear, &c., telegraph and telephone equipment and cables.

The Ninety-Second T.U.C.

The ninety-second annual congress of the Trades Union Congress is to be held at Douglas, Isle of Man, from September 5 to 9, and the general council's report reviewing its activities during the past year, and the agenda for the congress have now been published. The report recalls that at the 1959 congress the council reported that it was considering the issues raised by "Ministerial intervention" in collective bargaining in the nationalised industries and public services, but preliminary conclusions drawn by the general council from its study of developments in this field showed, the report states, that it had been impossible to prove conclusively by reference to statistics alone that the Government had exercised undue influence on the fixing of wages and salaries in these industries. The council asked the unions mainly concerned for their comments on the issues involved but, the report adds, the unions' replies did not show a marked measure of agreement about what might be done specifically to deal with the subject of the congress resolution. As a result of its examination, the conclusion reached by the general council was that it could deal with the subject in only the most general terms. Trade unions were bound to react in different ways to different instances of "Ministerial intervention," the report says, and a prerequisite for effective action was that they—and, in so far as it was involved, the T.U.C.—should seek to bring into the open the facts of Government intervention as they arose.

During the year, the report records, further representations have been made to the Minister of National Insurance for an immediate and substantial increase in benefits under both the National Insurance and Industrial Injuries Act. The general council has continued in its efforts to secure maximum safeguards for workers exposed to radiation risks. In its review of production and industrial development, the report points out that comparisons with other industrial countries and between similar firms in British industry have reinforced the general council's view that British industry in general could and should develop at a pace faster than the existing trend. The council has continued during the year to press the Government to move towards a more effective and co-ordinated policy for the fuel and power industries. With regard to the coal industry, the report warns that the reduced demand was inevitably leading to some contraction of the industry, and that the rapidity of this contraction was likely to lead to industrial and social difficulties.

Amongst the motions on the agenda for the 1960 congress is one dealing with the security of employment. Believing that security and continuity of employment are no less important than good wages and working conditions, the National Union of General and Municipal Workers requests the general council to examine the Law of Contract as it affects the relationship between master and servant, and to consider ways and means of securing implementation of the conclusions of the ILO technical meeting, held in December, 1959. A motion tabled by the Association of Scientific Workers expresses concern at the continued discharge of radioactive waste into the sea at three points on the British coast. The direction of industry to areas of high unemployment is the subject of motions by the National Union of Mineworkers and the Associated Blacksmiths' Forge and Smithy Workers' Society.

Iron Castings

The latest figures issued by the Joint Iron Council show that the total output of iron castings in the second quarter of this year was 1,006,300 tons. Compared with the first quarter, 1,032,900 tons, this is a reduction of 2½ per cent and is attributable to the incidence of the Easter and Whitsun holidays. The daily rate of output in the second quarter was fractionally higher.

In its analysis of the second quarter's figures the Council says that with the exception of castings for railway equipment, output was lower than in the first quarter of 1960. The second quarter's figure for engineering castings, which includes machine tool textile machinery, electrical, shipbuilding &c., was 2·8 per cent lower than the figure for the first quarter ; production of building and domestic castings dropped by 8·4 per cent between the two quarters, castings of pressure pipes and fittings dropped by 2·8 per cent and ingot mould production fell by 0·7 per cent. For each section, production in the second quarter of 1960 was higher than in the second quarter of 1959, the improvement being most noticeable for ingot moulds where the 1960 figure is 48·8 per cent higher than the 1959 figure.

The number of men employed in the iron-founding industry at the end of June, 1960, the Joint Iron Council reports, was 129,900.

PERSONAL AND BUSINESS

Appointments

MR. G. C. ROBERTS has been appointed commercial director of Fairey Engineering, Ltd.

MR. WILLIAM RONALD MILLS has joined Stanley Works (G.B.), Ltd., as general sales manager.

TUBE INVESTMENTS, Ltd., announces that Mr. C. H. T. Williams and Mr. E. G. Plucknett have been appointed to the board of directors.

GUEST KEEN AND NETTLEFOLDS (MIDLANDS), Ltd., announces the appointment of Mr. H. V. Bouldstridge, sales organiser of the screw division, as a director of the company.

THE MINISTRY OF TRANSPORT has announced the appointment of Mr. J. L. Paisley, M.I.C.E., as divisional road engineer, north western division, in succession to Mr. V. H. Haynes, A.M.I.C.E., who has retired.

THE BRITISH ROAD FEDERATION has appointed Mr. Geoffrey Palmer as its public relations officer in succession to Mr. Alan Havard, who has resigned to take up an appointment as assistant editor of *The Commercial Motor*.

THE MINISTRY OF AVIATION states that Mr. G. J. H. Jeffs, commandant, London Airport, is retiring from the public service on September 30. He will be succeeded by Mr. G. J. Warcup who is at present divisional controller, northern division.

BRITISH INSULATED CALLENDER'S CABLES, Ltd., has announced the appointment of Mr. D. G. Denoon as public relations manager of the B.I.C.C. Group. Mr. M. R. Thwaites has been appointed deputy public relations manager, and Mr. E. A. Still has been appointed assistant manager (advertising).

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., announces that the Rt. Hon. The Viscount Head of Throope has resigned from the board as a result of his appointment as the first High Commissioner in the Federation of Nigeria. Sir Joseph Latham has been elected a director. Mr. C. R. Wheeler has been appointed an additional vice-chairman of A.E.I. and will take up executive duties in 1962.

MR. G. A. SMITH, managing director of John Smith (Keighley), Ltd., a subsidiary of Thos. W. Ward, Ltd., has on medical advice resigned his appointment with effect from September 1. He is retaining his seat on the board as a director in a consultative capacity. Mr. Frederick Johnson, a director of the associated company, Thomas Smith and Sons (Rodley), Ltd., is taking over from Mr. Smith as a director and general manager, Mr. Charles Smith, local director, has relinquished his appointment with the company and has retired due to ill-health. Mr. Cyril Bland and Mr. E. C. W. Swann, local directors, have been appointed to the full board.

Business Announcements

HENRY BOOT AND SONS (PLANT), Ltd., Dronfield, Sheffield, has been appointed main stocking dealer for the John Deere Lanz industrial equipment.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd., states that Mr. F. A. Clifton has been appointed manager of the Birmingham private telephone department, A.E.I. telecommunications division, in succession to Mr. S. W. Hayes, who is retiring.

MATTHEWS AND YATES, Ltd., Swinton, Manchester, and TURNER AND BROWN, Ltd., Bolton, announce that they have jointly agreed to manufacture under the trade name "Turbro-Cyclone" a range of plastic chemical plant and equipment.

CHARLES CHURCHILL AND CO., Ltd., is moving its Manchester branch office and warehouse from St. Simon Street, Salford, 3, to 2-12, The Crescent, Salford, 5 (telephone, Pendleton 1382). The new premises will open for business on Monday, September 12.

WICKMAN, Ltd., Coventry, announces the assumption of sole selling rights in the United Kingdom for the machine tools produced by the Gisholt Machine Company, Madison, Wisconsin, U.S.A., and its associated subsidiary company Gisholt Machine Company (Great Britain), Ltd.

WALKER, CROSWELLER AND CO., Ltd., Whaddon Works, Cheltenham, Gloucester., has opened a new office block housing its sales and service departments. These departments retain the old address and telephone number (Cheltenham 56317). Departments at the factory, accounts, works offices, buying and publicity have a new telephone number (Cheltenham 56366).

FIRTH CLEVELAND INSTRUMENTS, Ltd., Treforest, Pontypridd, Glamorgan, Wales, states that its two home sales divisions have been merged into a home sales department. Mr. S. F. Smith has been appointed home sales manager and Mr. H. F. Bagley has been appointed deputy sales manager.

GEORGE WIMPEY AND CO., Ltd., announces that, to house its staff dealing with the design and procurement of chemical plants and oil refineries, it has acquired Flyover House, a new twelve-storey office block at the point where the Great West Road approaches the Chiswick Flyover.

RANKIN AND BLACKMORE, Ltd., Greenock, a member of the Lithgow Group, announces that it is to assemble Stork circulating pumps in Scotland. Mr. T. W. D. Abell, a director of the firm, is to make final arrangements with the manufacturers, G.B.R. Stork and Co., in Hengelo, in the next few weeks.

MICHELIN TYRE COMPANY, Ltd., states that a branch sales office has now been added to its Cardiff depot at Garth Street, Adamsdown, Cardiff (telephone, Cardiff 33948-9). Mr. W. B. Anthony is the divisional sales manager. Mr. O. J. B. Llewellyn is branch office manager and Mr. W. A. Griffiths is depot manager.

KELVIN AND HUGHES, Ltd., New North Road, Barkingside, Essex, states that the instrument components manufactured by the company are now marketed by the Industrial Division of S. Smith and Sons (England), Ltd. Inquiries should be addressed to Smiths Industrial Division, Components Section, New North Road, Barkingside, Essex.

DOWTY GROUP, Ltd., Cheltenham, has acquired Designex (Coventry), Ltd. The company designs and manufactures multi-spindle tooling and special-purpose equipment. Directors of the company are: Mr. J. C. G. Wegerif, chairman; Mr. E. G. Gibbons, managing director; Mr. W. Gibbons, Mr. Lionel Harper, Mr. W. Handley, Mr. J. D. Knight. Mr. E. R. Beattie has been appointed secretary.

THE METAL INDUSTRIES GROUP announces that Malcolm and Allan (London), Ltd., and Cable Jointers, Ltd., have amalgamated under one management and are now operating from 229, High Street, Acton, London, W.3, (telephone, Acorn 7811). Mr. E. J. Daws is now managing director of the two companies, which still retain their own names and serve their own particular branches of industry. Malcolm and Allan has vacated its London offices in Henrietta Street.

A.E.I. LAMP AND LIGHTING COMPANY, Ltd., states that Mr. R. H. Thornicroft, formerly superintendent of the traffic department at Leicester, has taken up a new appointment as deputy manager of the traffic department at A.E.I. (Rugby), Ltd. The distribution and traffic departments at A.E.I. Lamp and Lighting Company, Ltd., have been co-ordinated and Mr. E. G. Thomas has been appointed manager of both departments. Mr. R. C. Williams has been appointed superintendent of the traffic department.

Contracts

HEAD WRIGHTSON PROCESSES, Ltd., a subsidiary of Head Wrightson and Co., Ltd., has been awarded a contract to supply three induced draught cooling towers, with a total capacity of over 1,800,000 gallons of water an hour, for the new Spencer Works of Richard Thomas and Baldwins, Ltd.

WILLIAM BOBY AND CO., Ltd., Rickmansworth, Herts, has been awarded two contracts by the National Coal Board, valued together at approximately £13,000. Both contracts are for automatic dealkalisation/base exchange plants, one for Sutton Manor Colliery and the other for Altham Coke Ovens.

STURDY ENGINEERING, Ltd., has received an order for two multi-zone fully air circulated, radiant tube soaking pits from James Booth Aluminium, Ltd. The pits will have a working size of 23ft 6in by 7ft 6in by 14ft in depth to underside of lid, and have a total capacity of 120 tons of aluminium at a working temperature of up to 620 deg. Cent.

HALL, RUSSELL AND CO., Ltd., announces the receipt of an order from Parbel-Smith, Ltd., for three trawlers, two of which will have a length of 115ft 9in, while the third will have a length of 108ft 6in and be propelled by a National diesel engine driving a variable pitch propeller through gearing. The company has also received an order from the Pacific Steam Navigation Company, Ltd. for a tug measuring 90ft by 25ft by 12ft 6in and powered by Ruston and Hornsby diesel engines.

VOSPER, Ltd., has signed a contract with the Ministry of Defence of the Federal German Government to build two motor torpedo boats. Both craft will have a speed of 50 knots and be powered by Bristol Siddeley "Proteus" gas turbines driving through Allen reverse reduction gearboxes. One boat will have three main engines and the other two, and the generators will be driven by Rover gas turbines.

THE HEAD WRIGHTSON MACHINE COMPANY, Ltd., Middlesbrough, a subsidiary of Head Wrightson and Co., Ltd., is to supply a complete seamless tube mill to Tubes, Ltd., Desford, near Leicester, a member of the Tube Investments Group. The mill, valued at approximately £800,000, is for producing hot-finished alloy steel tubes between 2in and 6in outside diameter, and follows a previous order for a similar mill.

ASSOCIATED ELECTRICAL INDUSTRIES, Ltd. is to supply the complete drive and control equipment for six production lines at the new Spencer Steel Works of Richard Thomas and Baldwins, Ltd. The six lines comprise: $\frac{3}{16}$in hot-rolled coil cut-up line, $\frac{1}{4}$in hot-rolled coil cut-up line, side trim slit and recoil line, No. 1 fast cold coil cut-up line, light gauge line, No. 2 fast cold cut-up line. The contract, worth £339,000, is scheduled for commissioning by the end of September, 1961.

BRITISH AIRCRAFT CORPORATION, Ltd., has received an order for Vickers "Vigilant" (VIsual Guided Infantry Light ANti-Tank) weapons from the War Office; the order is for rounds for use in assessment trials, and is expected to be fulfilled early next year. The "Vigilant" was initiated about three years ago (see page 353, September 6, 1957) and in 1959 it was demonstrated to the United States Army at Redstone Arsenal. It has been proposed for use as the main armament of light-weight tanks in the United States. The applications envisaged include indirect fire under control from a helicopter, implying that wireless guidance has been proved practical. The normal guidance is by trailing wires; the system is such that each displacement of the thumb button corresponds to a given note of yaw or pitch, instead of the rate of turn building up as long as the button is deflected. A round, complete with control and sighting device, weighs only 45 lb.

Miscellanea

SUPPRESSION OF AEROELASTIC UNLOADING.—An objectionable characteristic of the swept-back wing is the large change in incidence of outboard sections with aeroelastic distortion, resulting in heavy or even complete unloading of the outer panels; to overcome this failing, such complicated solutions as the W and M planforms have been proposed. The August, 1960, issue of the *Journal of the Aerospace Sciences* contains a note by Edward J. Hopkins, Don W. Jillie, and Raymond M. Hicks, of N.A.S.A., "A Method of Reducing Aeroelastic Effects of Highly Swept Wings," proposing to stiffen the wing in flexure by introducing cylindrical camber about an axis parallel to the direction of flight: each half-wing is cambered about an axis in the mid-semi-span plane, so that in end view a gull wing appears; since "camber" is associated with curvature in the direction of flow, the term "warped" has been revived for such a wing. A study of a tapered "arrow" wing of 80 deg. leading edge sweep, aspect ratio 1·4, and section 12 per cent Clark Y normal to the leading edge showed that, for $q = 2400$ lb per square foot, a wing of solid aluminium would fall in lift coefficient from 0·019 to 0·013, rise in induced drag coefficient from 0·37 to 0·7, fall in $(L/D)_{max}$ from 12·8 to 9, and suffer neutral point movement from −0·3 to −0·1, due to flexibility. If the wings were warped so that each semi-span extended over one-quarter of a circle, there would be restored a lift coefficient of 0·018, an induced drag coefficient of 0·4, a $(L/D)_{max}$ of 12, and virtually the original neutral point. The penalty would be an increase in drag at zero lift from 0·0041 to 0·0045. This analysis was based on the assumptions that no bending occurred opposite the centre section and that no twisting took place, loss of lift due to twist being of the order 10^{-2} that due to bending, and took account of the loss of lift due to the reduced projected plan area. No discussion of the lateral stability of such a wing is given.

Deaths

WE have learned with regret of the death on Monday, August 22, of Mr. J. D. Millner, manager in the Irish Republic for Ferodo, Ltd. Mr. Millner, who was fifty-three years of age, joined the sales organisation of Ferodo, Ltd., in 1927. He was appointed manager in the Irish Republic in June last year.

CONTINENTAL AFFAIRS

by Our Continental Editor

Autostrada del Sole: Bologna—Florence

After four years of work, about 44 per cent of the total length of 738 km of the Milan–Naples "Autostrada del Sole" will have been completed by the end of this year, at a cost of 62,000 million lire. In addition to the sections Milan–Bologna and Capua–Naples which are already in service, the important section across the Appennines between Bologna and Florence will be ready by November. After briefly outlining the project, the present article describes the 87 km long Appennine section of the motorway which is characterised by a very high proportion of bridges and tunnels, amounting to no less than 27·5 per cent of the total distance.

FOUR years have passed since the setting up of the first milestone at San Donato Milanese marked the beginning of one of the major post-war Italian development projects : the construction of a modern motorway between Milan and Naples.

Throughout its length of 738km, the "Autostrada del Sole" is to have an overall width of 24m, comprising two 7·5m wide carriageways with 3m shoulders (of which 2·5m will be surfaced) and a 3m wide central reservation (Fig. 1). Scheduled for completion in 1963, the "Highway of the Sun" will form a major traffic link between the industrial North of Italy and the still largely agricultural South. It will, therefore, play an important economic role by facilitating long distance goods transport as well as speeding up passenger traffic.

The corporation whose job it is to construct and operate the "Autostrada del Sole," the Società Concessioni e Costruzioni Autostrade p.A., of Rome, signed a thirty-year agreement with the Italian Government on April 14, 1956, which sets out the terms of the concession and the operation of the road as a toll highway on the lines of the American turnpike roads. At that time, the so-called S.I.S.I. Project, on which the agreement was based, had been worked out in detail only for the 48km from Milan to Piacenza, the rest was merely a line on a map of 1 : 25,000. However, in order to maintain the impetus of the undertaking and the enthusiasm of all concerned, including the public and the Government, it was considered essential to push on quickly, and by December, 1956, with provisional finance through I.R.I., contracts for the first twenty-six lots of 7km–8km each had been signed, involving a total of 43,000 million lire. At that time, the staff consisted of some twenty persons. (It has remained the policy of the Corporation to minimise "bureaucratism" and to work chiefly through its consultants and contractors.)

The overall project for the Autostrada del Sole is due to Professor Ing. F. Aimone of Milan Technical University. Detailed plans were worked out by Italstrada S.p.A. as far as the road and engineering works were concerned, and by the Corporation with regard to the stations, service areas, and ancillary installations.

Since the award of the first contracts in the northern and southern sections on June 22, 1956, rapid progress continued to be made. A year later, work was proceeding on all sections between Milan and Florence, and Naples and Capua. On December 8, 1958, the official opening took place of the sections Milan San Donato–Piacenza Nord (50km), and Piacenza Sud-Parma (about 52km). Shortly afterwards, on February 16, 1959, the stretch from Capua to Naples (40km) was handed over to traffic. With the completion in March of the 1176m long bridge across the Po, and its commissioning on June 15, the connection between Piacenza Nord and Sud was established, and at the same time the 60km section from Parma to Modena came into service. Exactly one month later, with the completion of a further 37km, the highway reached Bologna.

By July, 1959, therefore, 195·3km had been completed between Milan and Bologna, at a cost of 27·5 milliard lire, and a further 40km between Capua and Naples, making in all about 235km or nearly one-third of the whole length.

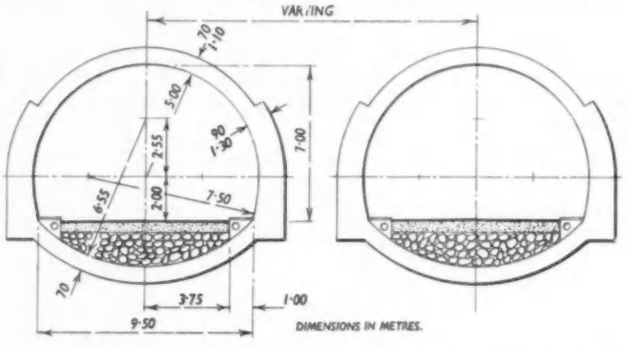


Fig. 2—Characteristic tunnel section. The lining thickness at the crown ranges from 0·7m to about 1m. Roadways are paved

Fig. 1—Autostrada del Sole between Parma and Modena. Each carriageway is 7·5m wide, with a 3m shoulder on the nearside and a central reservation of 3m width separating the two directions

The next stage which lay ahead was the crossing of the Appennines between Bologna and Florence. In the Appennine mountains, the ruggedness of the terrain and difficult geological conditions substantially added to the cost of construction, due to the nature and extent of the engineering works which were found to be required. On this approximately 87km long section, no less than 27·5 per cent consists of bridges and tunnels. This part of the work is now well advanced and is scheduled for commissioning in November. By the end of the year, therefore, there will be in being nearly 44 per cent of the whole of the "Highway of the Sun," including the most difficult and expensive portion. Overall construction costs up to that date will amount to 62,000 million lire.

Appennine Section

The Bologna–Florence section extends from km 193·655, just before the Bologna Nord Station, to km 279·625, slightly past the Firenze–Ovest Station at km 279–625, near where the motorway from Florence to the sea, the "Firenze–Mare," will underpass the Highway.

Over its total length of about 87km, the proportion of engineering works, bridges and tunnels, is very high, owing to the need to cross very rugged terrain smoothly and without the gradient exceeding anywhere 3·75 per cent. The following gives some idea of what was

Fig. 3—The Quercia–Setta viaduct, a curved bridge of thirty-five reinforced concrete spans, of 1070m total length

Fig. 4—Sambro viaduct under construction (September, 1959). The central span is 140m

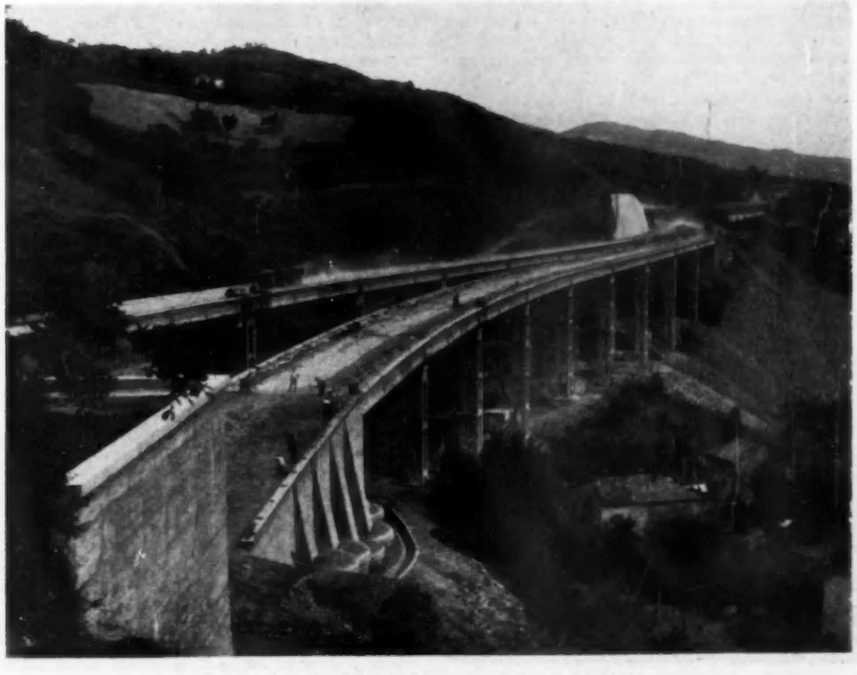


Fig. 5—Piazza viaduct nearing completion (July, 1960)

involved : there are some eighty bridges and viaducts with spans of 10m or more, totalling in length 16262m. Bridges of less than 10m span number 273 and total in length 1247m. There are twenty-three tunnels with a combined length of 6155m and three cut-and-cover tunnels (built in order to prevent landslides) which together are 541m long ; an overall total of 24,205m.

Parts with different gradients are connected by convex or concave stretches with 5000m minimum radius. The minimum radius in the curves is 250m, but like the maximum permissible gradient of 3·75 per cent this figure is reached but rarely. Everywhere a clear view ahead is maintained of at least 180m. The criterion has been to make it possible everywhere to maintain a minimum speed of 100km per hour.

The standard width of the carriageways, shoulders, &c., is the same on the Appennine section as elsewhere except that on occasions, depending upon the nature of the terrain, the two carriageways run independently.

The bottom stratum of the Bologna–Florence section consists of a layer of crushed rock 20cm thick, followed by 5cm of macadam, 10cm of bituminous conglomerate, a 4cm thick binder, and a 3cm thick wearing course. No concrete is used anywhere, partly for reasons of cost and partly because of the better resistance of a black-top road to differences in temperature.

The bridges are twin-structures, and the tunnels, in view of the considerable width of the roadway, are built as separate tunnels for each direction. These may be side by side, but often they are separated by varying amounts as shown in Fig. 2.

The tunnel section shown in the illustration is one which, with small variations, is generally used, the principal change being with regard to the lining thickness which can reach up to 1·5m at the sides.

Geologically speaking, the Emilian-Tuscan Appennines belong to a number of geological periods, mostly the mesozoic and cenozoic, especially cretaceous and miocene. Along the route of the Autostrada the subsoil is mostly flysch, with continual alternation of clayey schists, marl, limestone marl and sandstone, while in the valleys are found alluvial strata of gravel and sandy clays. Foundation work was particularly difficult and rendered it necessary to construct at many points elaborate retaining walls reinforced all over with wire-mesh.

Tunnel construction in general was by the Italian method, a modification of the Belgian method, with a pilot tunnel at the bottom. All tunnels are heavily lined.

Description of Route

At Bologna Sud–Casalecchio di Reno (km 193·7), the "Autostrada del Sole," which, from Milan, has been following an approximately south-easterly direction, turns sharply south into the foothills of the Appennines. Following the valley of the Reno on the left, it crosses to the right bank just before the station of Sasso Marconi at km 205·7. The road then leaves the valley of the Reno on its right and ascends that of the River Setta, proceeding partly along the bottom of the valley and partly along the slopes on the right bank. Near Vado, the route crosses the Setta, recrossing again at La Quercia, by a curved viaduct of thirty-five reinforced concrete girder spans, totalling 1070m in length (Fig. 3).

Just behind Rioveggio (km 221·3), which is the next station, lies the Sambro Bridge (Fig. 4), with a central arch of 140m spanning the river of that name, a tributary of the Setta. The gradient, which slowly has been increasing, now reaches the maximum, about 3·75 per cent, which is maintained for 4½km as far as the 416m long Serra Ripoli tunnel. Behind this tunnel are situated the bridges over the Rio Vallardino and Rio della Piazza (Fig. 5), with the 175m long gallery of Le Serrucce in between. The road is now nearing the top section, with reduced gradients which vary between zero and 3 per cent. Another major viaduct here is the Voglio which crosses the deep gorge of the river in five arch spans.

The Pian del Voglio Station (km 235) is now reached, and the highway continues through

CONTINENTAL AFFAIRS *(Continued)*

the Sospara tunnel (a double tunnel, the two parallel sections being 355m and 372m long), to reach the important viaducts over the Fosso della Madonnina and the Fosso del Biscione, the latter an arch bridge with a 130m central span. After a level stretch here of about 2½km, the road rises again, crossing the Merizzano (two spans of 95m each) (Fig. 6) and the Gambellato and continuing over the Fosse della Volpe and the Poggetone–Pecora Vecchia viaducts, finally reaches the highest point, 733·3m above sea level, at the 846m long Citerna tunnel at km 244·7.

The Autostrada now descends towards the station of Barberino di Mugello (km 260), initially with a more or less constant gradient of 3 to 3·78 per cent. This section represents perhaps the most difficult part of the terrain, comprising over the next 6½km, in addition to the Citerna, seven further tunnels (Monte Spicchio, 380m ; Sette Fonti, 460m ; Castagno al Monte, 337m ; Poggio Palina, 164m ; Massa, 140m ; Castello, 264m ; and Villanecchio, 168m) as well as five or six major viaducts. The latter include the only steel bridges on this route, two plate girder bridges over the Poggiolino, with a total length of 532m, comprising a total of twelve spans, the longest being one of 60m.

These bridges lie between the Citerna and Spicchio–Sette Fonti tunnels. Among other important bridges in this area we mention the Sette Fonti viaduct, the viaducts over the Fosso delle Macinaie and over the Fosso La Corretta.

At the exit of the Castagno al Monte tunnel, danger arises from cross-winds owing to the exposed position of the following Macinaie Viaduct. At this point, therefore, a system of anemometer-controlled light signals will be installed to warn drivers of conditions to be expected on emerging from the tunnel.

Before leaving this section, mention must be made of the bridges over the Fiumicello, Torre Aglio, and Torre Lora. The first of these, which may be taken as typical, comprises a number of spans consisting of *in situ* concrete girders supported on columns measuring 1·5m by 1·66m at the base and 1·5m by 0·8m at the top. These columns, which are grouped in pairs, are of considerable height, up to 51·5m. Each pair is joined by two cross-beams, one about 5m below the top, the other near the base. The bridge comprises two identical halves, one for each roadway, and is curved.

The most important bridge in this group, and one of the major structures of the Bologna–Florence section, is the 440m long and 100m high Aglio Viaduct (Fig. 7). This comprises an elegant double arch of 164m span rising to a height of over 80m above the abutments. The arch, which is 8m wide throughout, has a hollow box section with 0·4m thick walls ; the depth of the section varies from 1·9m at the crown to 5·5m at the abutments.

Fig. 7—Aglio viaduct, with a central arch of 164m span and 84m height. The overall length is 440m (July, 1960)

For the construction of the arches, tubular steel centring (Dalmine) was employed. After casting one arch, the centring was traversed into position for the second.

The bridge over the Torre Lora is a prestressed concrete design over four spans, the longest being 44m ; these are the longest prestressed spans of the route.

After Barberino, the road rises again for about 4km, to reach 396m above sea level at the entrance to the Croci del Calenzano tunnel (length, 843m). Thereafter it descends all the way towards the station of Prato Calenzano (km 276·8), and the exit at Firenze Ovest (km 279·6), the gradient varying from 3·77 per cent down to about 1·5 per cent. This section, although there are only two smaller tunnels (135m and 140m long respectively), is also characterised by the large proportion of viaducts, in particular the two bridges over the Fosso Goccioloni, and those over the Rio Valletta, Rio Corzanello, La Cassiana, Formicaio, and others. The most important here from the point of view of its length, is the viaduct crossing the Torre Marinella. This 450m long bridge consists of individual 30m spans, each supported on pairs of columns spaced 5m apart. These columns which are hollow and measure 1·6m o.d. by 0·9m i.d. were cast with the help of sliding shuttering. They are connected across the top by a concrete cross-beam on which rest six 2·4m high reinforced concrete beams, with a width of 0·45m across the flange and 0·25m thickness at the web. As in the case of the other bridges, the two halves are structurally separate from each other, except for the connection formed by the central reservation.

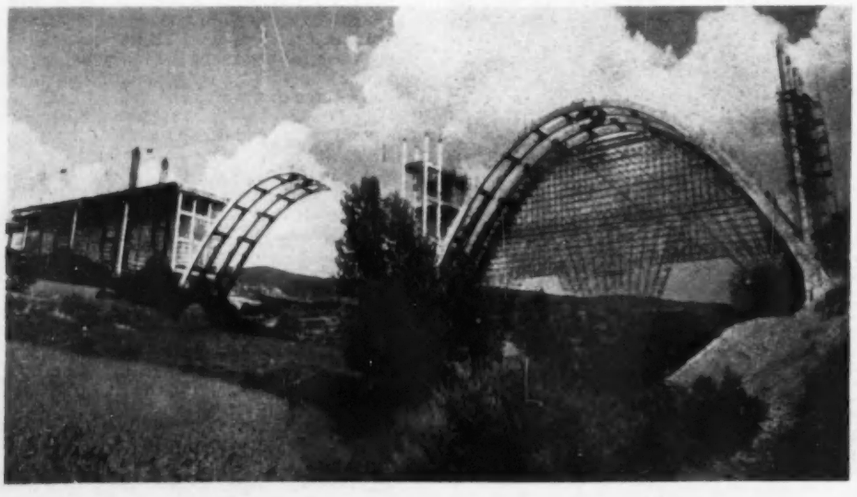


Fig. 6—The two 95m spans of the Merizzano viaduct under construction (September, 1959), showing the tubular centring employed

General

For purposes of construction, the road is organised in four zones : " Bologna " (with headquarters at Casalecchio di Reno), " Pian del Voglio " (with headquarters in that locality), " Citerna " (with headquarters at Dogana, near Barberino di Mugello), and " Firenze " (with headquarters at Barberino di Mugello). The first of these zones extends from Casalecchio to Vado and, in the other direction, to Rubiero in the Po Valley. The four zones were subdivided into twenty-three lots which were mostly let on the basis of private tenders. Only in the case of seven lots—the most important engineering works—was the award made on the basis of a design competition. At Citerna, over the most difficult stretch of about 5km the work is under the direct control of the Corporation. Each contractor is obliged to set up a laboratory on the site to carry out all necessary tests. Such tests are frequently checked by duplicate runs in official laboratories. For mass concrete, samples were tested at the rate of one per 500 or 600 cubic metres. In the case of major structures, tests were carried out for each functionally important member. The types of cement employed included pozzolanic cement, blast-furnace cement, and standard Portland cement of grades " 500 " and " 680." Aggregates and sands were obtained from the rivers Sette and Reno. Elsewhere, some difficulty was encountered in finding suitable material, and recourse was had to alluvia of certain streams which, however, required very thorough washing, and to a few quarries capable of supplying the necessary qualities. Surfacing materials are produced in factories at various points and transported to the road by lorries. In order to ensure uniformity, the laying of the top courses, which is done by machine, is carried out directly by the Corporation. About 8000 people are at present employed on the project, together with 2000 machines.

Axial Multiple Plunger Pump

For covering a dual pressure range by means of the same pump, the Swiss Locomotive and Machine Works (SLM), Winterthur, has developed a design of axial multiple plunger pump, the delivery of which automatically changes, depending on the pressure in the system. For example, the model "A63-10" has a low-pressure delivery of 5 litres per minute at 50 kg per square centimetre and a high-pressure of 0·9 litre per minute at 400 kg per square centimetre. The largest of the five models delivers 220 litres per minute at 30 kg per square centimetre and up to 20 litres per minute at 400 kg per square centimetre. This gives merely an outline of the capacities available, as each model is available in a number of different versions. The pumps are directly driven by vertical flanged motors of 1 h.p. to 30 h.p.

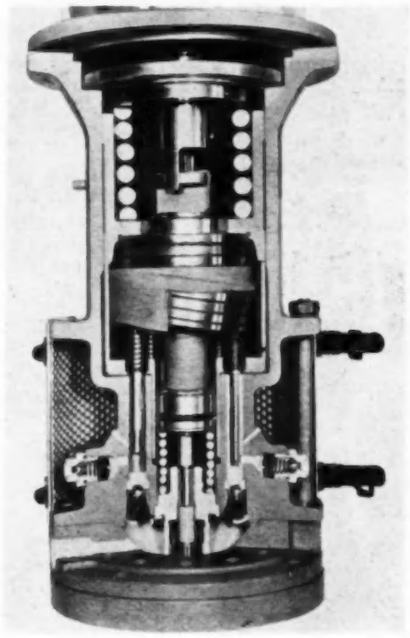


Fig. 1—Section through pump, showing spring-loaded floating swash plate which drives a combination of large and small bore axial pistons. Above the inlet valves, the overspill ports which in the case of small pistons are closed by sleeves : one half of the oil filter is seen behind the pump

The manner of functioning is illustrated in Fig. 1. Twelve plungers are equally spaced on a pitch circle about the axis, and are held against the inclined swash plate during the suction stroke by compression springs seated in an axially sliding casing. Inlet and delivery ports are provided with spring-loaded ball valves. The swash plate is mounted on thrust bearings in a spring-loaded sliding housing so that the plate can move vertically in balance with the oil load on the pistons. The casing housing the piston springs is connected to the swash plate housing and moves with it.

The stroke of the pistons always remains the same. With low delivery pressure, the assembly is in its bottom position. In this position, the edges of the large pistons at top dead centre do not reach the overspill ports arranged in each cylinder. As the delivery pressure rises, the pistons move upwards, and more and more of the stroke volume is spilled through these ports, until in the topmost position the delivery is zero. The small pistons, on the other hand, run in sleeves which close off the overspill ports, so that a constant quantity of oil is delivered whatever the position of the swash plate.

This particular combination of large and small pistons determines the pump characteristic (Fig. 2). In the lowest portion of the system, all pistons give a full delivery which is nearly constant up to the pressure at which the swash plate begins to lift and the spill ports are being uncovered. The oil quantity then drops until the ports are fully uncovered, and thereafter the only delivery is that arising from the small pistons which is nearly constant up to the maximum pressure. Variation of the pump characteristic is possible by means of suitable combinations of large and small pistons.

If it is desired to have a pump with an adjustable rate of delivery, it is possible to replace the main swash plate spring by a wormgear-driven screw spindle by which the desired delivery can be set. The volume delivered, it is stated, is substantially constant over the full range of pressures from 0 kg to 400 kg per square centimetre.

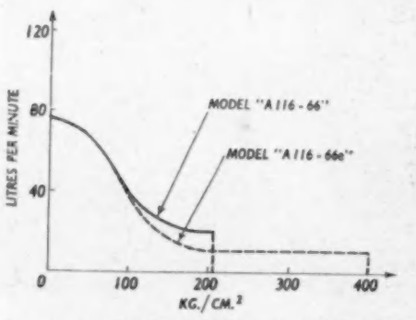
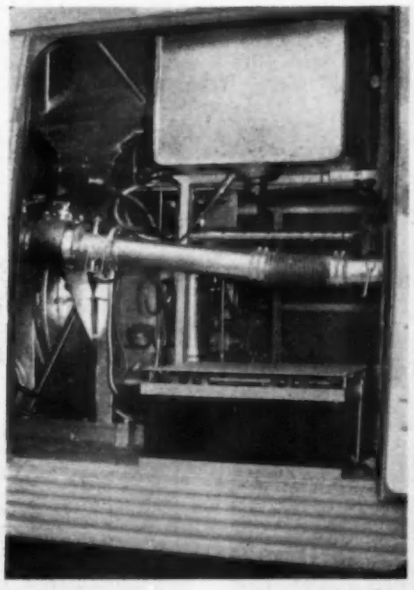


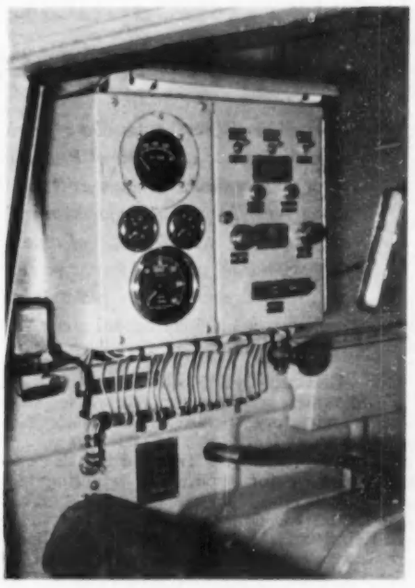
Fig. 2—Typical characteristics of "SLMaxial" multiple-plunger pump

Air Bleed Turbines

Principally for "cold" air starting of the main engines of Douglas DC-8 and Convair "Coronado" jet air liners, the Swiss Air Transport Company, Ltd., has ordered six turbine air starters from Auto Diesels, Ltd., of Uxbridge, Middlesex, concessionaires for engines manufactured by the Standard Motor Company, Ltd. The original Standard gas turbine was a fixed shaft engine designed for low cost per horsepower developed ; it was described on March 15, 1957, page 406. The basic unit has now been developed to give the heavy bleed necessary for the rapid starting of large engines, mainly by refinement of the compressor itself—an automatic blow-off valve is now incorporated—and a satisfactory overhaul life has been achieved. The sets used by Swissair are mounted in Ford FK 1000 vans with the body panels heavily damped ; our illustrations show the installation in some detail. Points that may not be evident are that English is the standard language for Swissair equipment, and that the sight glass for the turbine fuel tank is on the driver's side of the control panel, the mirror being fitted so that it is visible through the window of the near, starboard, cab door. It will be noticed that, in contrast to the original, shaft power, engine, the working parts are completely enclosed.



Turbine installation seen through nearside door : in the foreground is the delivery duct, with the electrically operated main air valve at its upstream end. The turbine fuel tank and air intake ducting are conspicuous as is the heavy acoustic damping of the vehicle body



Nearside of the cab : the delivery duct is seen to the left of the engine cowling. On the bulkhead are mounted the all-electric remote control panel and the instrument display. The engine speed indicator has a revolution counter calibrated in terms of hours at governed speed

Research Reactor "Diorit" Critical

The Swiss research reactor "Diorit," installed at the Würenlingen nuclear centre, went critical for the first time on August 15. The official commissioning took place on August 26. "Diorit" is to have a thermal output of 12·5MW which may be doubled later. It has a core of about 5·9 tonnes of natural uranium, moderated by 9·6 tonnes of heavy water. Maximum design thermal neutron flux is $2{\cdot}2 \times 10^{13}$ neutrons per square centimetre per second. The Würenlingen installations, which also include the "Saphir" swimming pool reactor, were erected by Reaktor A.G., a company formed by private industry under the leadership of Brown, Boveri et Cie, Baden, and with Government support. Under an agreement recently concluded with the Federation, the Würenlingen Centre has been taken over by a Federal Institute of Reactor Research which is connected with the Swiss Federal Polytechnic (E.T.H.).

Heat Treatment Congress

The Sixteenth Heat Treatment Colloquium, 1960, will take place at Wiesbaden on October 13 and 14. The event, which last year attracted 700 experts, including 100 foreigners, is being organised by the Wissenschaftlich-Technische Arbeitsgemeinschaft für Härtereitechnik und Wärmebehandlung e.V., in conjunction with the Institut für Härtereitechnik, Bremen, Postfach 13, Postamt Bremen-St. Magnus (to whom all inquiries should be addressed). The provisional programme of lectures includes a plenary lecture by Professor Dr. Egger and co-workers, Vienna, on "Metal working enterprises in the Norico-Roman town on Mount Magdalensberg near Klagenfurt," as well as eleven papers and a conversazione.

THE AMERICAN SCENE

by Our American Editor

Inert Atmosphere Processing Facility for Refractory Metals

An advanced inert atmosphere fabrication facility for refractory metals was recently put into operation at Bridgeville, Pennsylvania, by the Universal-Cyclops Steel Corporation. Known as "InFab," the new plant was designed and constructed by the firm in conjunction with the U.S. Navy Bureau of Naval Weapons and represents the beginning of a new era in metallurgy. The facility comprises forging, rolling mill and furnace equipment and employs a 99·995 per cent pure argon atmosphere. The plant is designed for remote-control operation, but operators wearing space suits can enter the work area through a special lock.

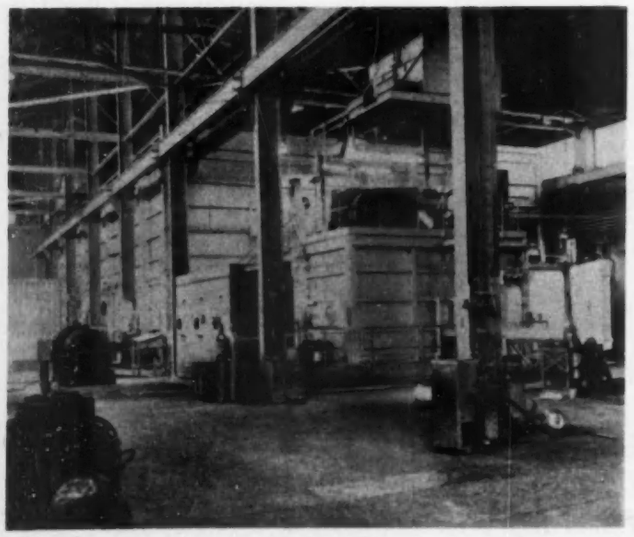
The Universal-Cyclops Steel Corporation, Bridgeville, Pennsylvania, has started producing refractory metals of unusually high integrity in its remarkable new "InFab" (Inert-Fabrication) facility. These materials offer great promise for applications requiring high strength at ultra-high temperatures. "InFab" was conceived, designed, and constructed by the Refractomet Division of the firm in technical co-operation with the U.S. Department of the Navy, Bureau of Naval Weapons. Its purpose is the production of high integrity mill products of the refractory metals such as molybdenum, columbium, tantalum, tungsten, and their alloys. These metals are currently being produced on specialty steel mill equipment which is far from ideal because of their metallurgical characteristics and does not permit the full utilisation of the inherent properties of the materials. Refractory metals should be hot-worked at temperatures double those possible in conventional mills. Molybdenum at these temperatures oxidises catastrophically, and all refractory metals are contaminated by elements in air. Therefore, it is necessary to prevent contact with normal atmosphere during processing at high temperature. For this reason, the "InFab" enclosure is filled with inert argon gas.

The "InFab" facility is a welded steel enclosure 42ft wide by 97ft long by 23ft high (Figs. 1 and 2). Inside the enclosure are an impactor, a rolling mill, furnaces, a 10-ton crane and space for additional equipment. Forging and rolling of these refractory metals is performed at temperatures up to 4500 deg. Fah. in the protective atmosphere of the argon gas. The complex respiratory system employed cools, conditions and purifies the argon atmosphere in the facility to a purity level of 99.995 per cent. This purity level is unique and far exceeds the commercially available levels. During operations the temperatures in the facility range from 80 deg. to 100 deg. Fah.

The impactor, rolling mill and furnaces were designed to be fully automatic and are controlled from consoles outside the facility. Each console has a full view of the operations it controls through a special glass "picture window" which shields against any harmful ultra-violet rays emitted from the white hot metal. Some manual handling is required in taking materials into the facility and transferring them between the equipment. This is accomplished with the aid of the crane. It is planned to conduct experiments on hot machining and welding of these materials within the facility in the near future. These functions require personnel to be inside the room.

Fig. 3—Operator wearing "space suit" and oxygen supply and cooling unit entering facility through personnel lock

The "InFab" technicians are dressed in a modified design of future space suits. The suit is a modified U.S. Air Force MC-2 pressure suit and consists of five layers of clothing: (1) An insulated knitted undergarment. (2) A ventilation suit, permitting complete distribution of air around the body at the rate of 8 to 10 cubic feet per minute at 74 deg. Fah. and 40 per



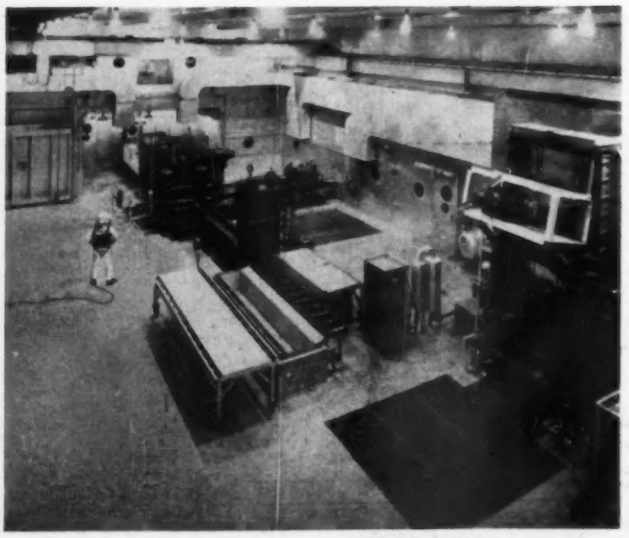


Fig. 1—(Left) Exterior view of "InFab" facility, with argon gas purification plant, control consoles and ingot preparation plant. Fig. 2—(Right) Interior view of "InFab" facility, with impactor, rolling mill and furnaces

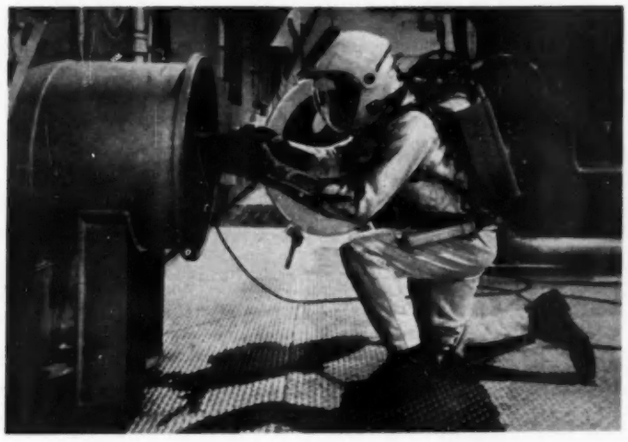


Fig. 4—Molybdenum ingot being passed into facility through tube-shaped materials lock

cent humidity. (3) A second insulating garment. (4) A gas-tight blouse and trouser assembly, permitting a high degree of mobility. (5) A reflective aluminised outer garment, which shields against thermal radiation and protects the gas-tight inner suit. The headpiece is of fibre-glass and plastic material and is non-fogging, and special gloves and boots complete the assembly. The air supply and a cooling unit are contained in a pack carried on the technician's back. Power supply and communication lines connect to outlets in the plant.

Personnel entering "InFab" first enter an air lock (Fig. 3). After the outer door is locked, the flush cycle begins. Nitrogen replaces the air in the lock and at a predetermined oxygen level argon is admitted. The cycle is completed in three to five minutes. The inner door is then opened and the technician is inside the facility. He immediately connects his communications and power supply lines to strategically situated outlets in the room.

The material lock is operated by evacuating the air and replacing it with argon while transferring material into or out of the room. The lock is a cylindrical chamber 2ft in diameter and 16ft long, (Fig. 4). It contains roller tables to facilitate handling. The equipment lock permits the entry and exit of large pieces of equipment and large quantities of material without the loss of the enclosure argon atmosphere. As no personnel are involved the air is evacuated and replaced by argon during the entry cycle. The chamber is 8ft wide by 16ft long by 8ft high. There are also two emergency personnel exits consisting of quick transfer locks for immediate exit from the room.

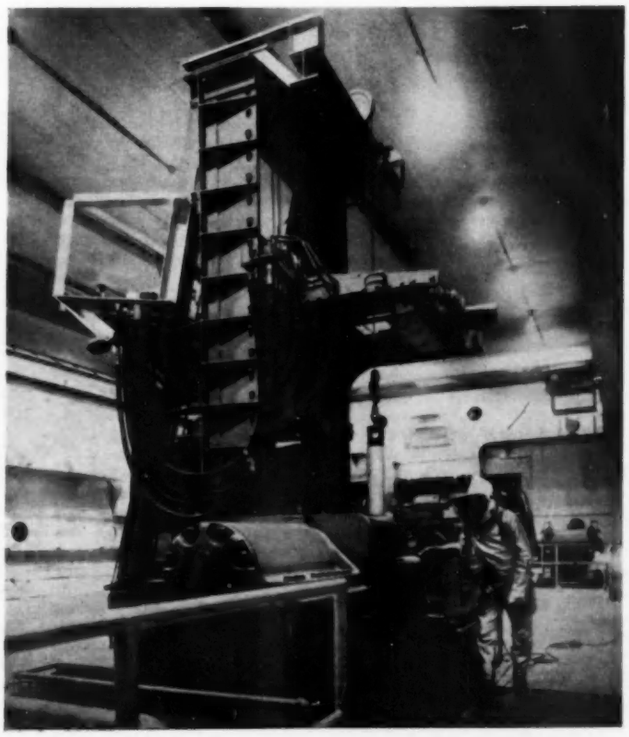
The refractory metals are formed from metal powders by compaction and sintering into electrodes and are melted into high quality ingots in a specially designed consumable-electrode vacuum arc furnace. It is in the next steps for producing mill products through forging and rolling, that "InFab" depart radically from past practices. Under the force of a horizontal impactor, ingots are broken down into billets or sheet bar at temperatures up to 4500 deg. Fah. in the protective argon environment. The fully automatic, remote control impactor hits the ingot on two sides with 15,000 ft-lb of force. Since deformation takes place equally on both sides of the ingot, more uniform billets and sheet bars are obtainable. The ingots are heated in induction furnaces situated immediately below the forging zone. The close proximity allows the transfer of the ingots into forging position in two seconds and keeps heat losses to a minimum. The normal products of the impactor are 4in round-cornered square billets and sheet bars 2in by 10in cross-section.

The Chambersburg type "A" impactor (Figs. 5 and 6), is a horizontal forge which is driven by compressed argon gas. Its maximum capacity is 15,000 ft-lb per blow, and two dies provide equal deformation on two sides. The die faces are 7½ by 15in; the floor space occupied by the machine is 15ft 3in by 3ft 2in. The automatically controlled manipulator accommodates ingots up to 12in diameter. The impactor is fully automatic and is normally controlled from a console outside the room. The large picture window viewing the impactor is of special composition glass to screen out harmful ultra-violet radiation emitted from the glowing white metal. Additional controls are situated within the enclosure for emergency use.

Situated immediately beneath the impactor dies and within close proximity are the "Inductotherm" heating furnaces. Three high-frequency induction heating coils are mounted on a car which can be positioned automatically. These water-cooled induction furnaces are 7in, 10in and 13in in diameter, respectively, to obtain added flexibility. Another car may be positioned under the point of forging to take material away after forging. These furnaces are capable of heating material to 4500 deg. Fah.

If further processing is desired, the billet and sheet bar are transferred to the rolling mill area. They are then heated in a graphite-lined indirect induction furnace at the end of the rolling mill table. A molybdenum liner inside the furnace protects the metal from reaction with the graphite. The "InFab" rolling mill rolls refractory metals into bar and sheet at temperatures up to 4000 deg. Fah. as compared to conventional rolling practices where steel is rolled at temperatures up to 2300 deg. Fah.

The Birdsboro rolling mill, Fig. 7, resembles a miniature blooming mill. It is a 16in by 36in two-high mill complete with motorised screw-down and automatic feeding equipment. The mill has hydraulic roll balance, anti-friction journal bearings, hydraulically operated mill stand, and front and back motorised roller tables. The bar turner and special pinch rolls are equipped with an indexing device which moves back and forth to accept stock for faster and more accurate processing. A hydraulic alligator shear at the end of the front roller table removes splint bar ends and defective



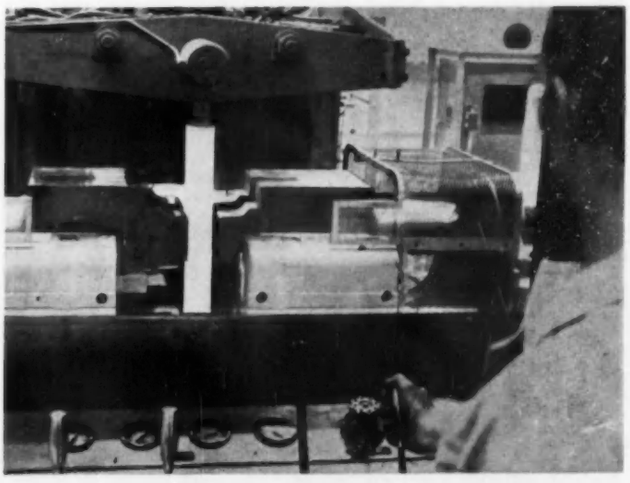


Fig. 5—(Left) Manipulator lowering molybdenum forging ingot into induction furnace situated below the impactor forge

Fig. 6—(Above) Operation of the horizontal impactor forge viewed through a window from the remote control station outside the facility

THE AMERICAN SCENE *(Continued)*

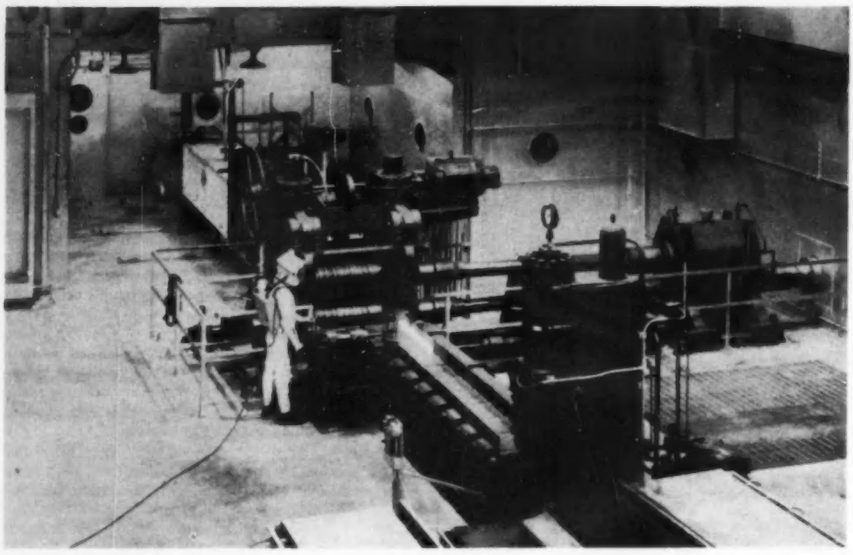


Fig. 7—Hot rolling of molybdenum bar stock at 4000 deg. Fah. on the 16in by 36in two-high rolling mill

areas, and is automatically operated from the console. The console situated above the mill and outside the enclosure is similar to the console for the impactor and permits completely automatic remote operation. Additional controls are situated within the enclosure for emergency use.

Two "Inductotherm" indirect induction heating units, similar to those at the impactor, are situated at the end of the rolling mill table. They may be automatically positioned for feeding material to the motorised roller table or for returning material to the furnaces. They are designed to heat material to 4000 deg. Fah. The mill is equipped with both flat and grooved rolls and can produce bars down to ½in diameter and sheet up to 15in wide and 96in long. When using pack rolling, a sheet gauge of 0.020in is obtainable.

The "InFab" enclosure is filled with argon maintained at a pressure of ½ oz per square inch above the atmospheric pressure outside the enclosure by means of a pressure balance system (Fig. 8). The room atmosphere is continuously changed and purified to maintain an argon purity level exceeding 99.995 per cent. During operations, due to the high temperature of material being fabricated, argon leaves the room at a maximum of 120 deg. Fah. and is returned to the room at approximately 30 deg. Fah, maintaining an average temperature of 80 deg. to 100 deg. Fah. Specifications which have been surpassed in actual operation call for the argon entering the system to contain the following gases at these approximate levels: nitrogen, 150 p.p.m.; oxygen, 40 p.p.m.; water vapour, 50 p.p.m.; oil vapour and other hydrocarbons, 5 to 10 p.p.m. The argon purification system was designed, constructed and installed by Air Products, Incorporated.

The production of refractory metal mill products starts with powder metallurgical techniques and is followed by consumable electrode vacuum arc casting. Fine metal powders are fed into a bag loading device, where they are formed into a controlled shape through means of vacuum and mechanical agitation. The isostatic compactor takes the powdered mix in its plastic container from the first step and compacts it into an electrode of uniform shape and density. A Lindberg sintering furnace strengthens and futher refines the compacted electrode. Densities of 90 to 95 per cent are obtainable and undesirable gaseous elements are eliminated through controlled heat and atmosphere. The compacted sintered electrode is now ready for melting. A specially designed General Electric consumable electrode vacuum arc furnace produces ingots of consistent quality and composition. Gaseous impurities in molybdenum are held within a few parts per million range. The furnace produces 12in diameter ingots, 70in long, weighing up to 3000 lb. Additional facilities at Universal-Cyclops permit the preparation of refractory metal ingots 16½in in diameter by 70in in length, weighing approximately 6000 lb.

The ideal fabrication conditions of "InFab" permit the elimination of many conditioning and annealing operations necessary under current processing practices. It is anticipated that the higher product yield and the reduced number of processing operations may permit the production of vastly superior refractory metals and their alloys at the approximate cost level of these metals in the forms now commercially available.

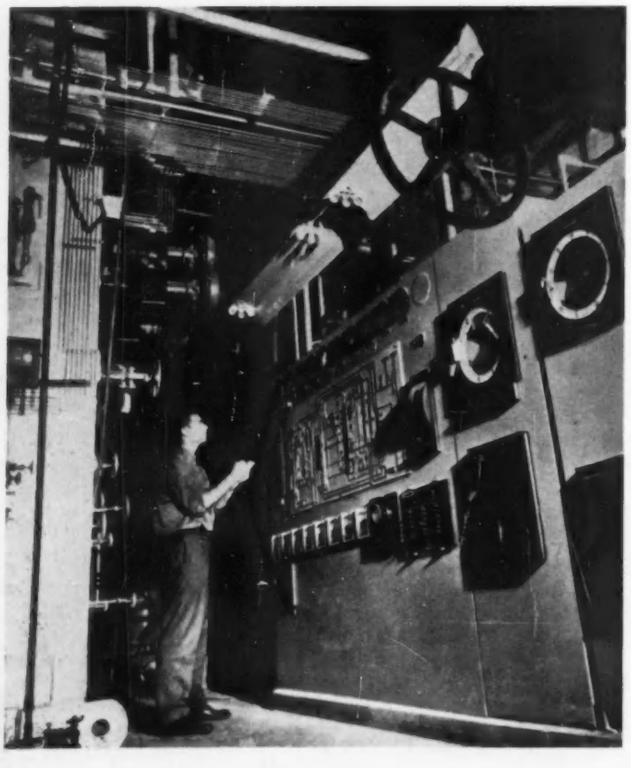


Fig. 8—Controls of the argon gas circulation and purification system outside the plant

Gallium Arsenide Diodes

Gallium arsenide has been found to possess properties making it superior to silicon or germanium in many high-frequency diodes. Some characteristics of point contact diodes using this material have been described in a paper presented to the I.R.E. Professional Group on Microwave Theory and Techniques by Mr. W. M. Sharpless of the Bell Telephone Laboratories. Among the factors listed by Mr. Sharpless which contribute to improved performance is the high energy gap, which enhances the possibilities of high-temperature operation, while the high electron mobility and low dielectric constant improve the high frequency performance. In addition to the use of the diodes as variable reactors, point contact rectifiers prepared from gallium arsenide have been used successfully by various investigators at the Laboratories in such applications as first detectors operating into the millimetre wave range and in the X band (11 kmc), and as high-speed switching diodes which have shown no minority carrier storage effects for switching times of the order of 10^{-10} sec.

Significant improvements in noise figure results are reported when the diodes are operated under refrigeration. For instance, in a typical diode used as a variable reactance element in a parametric amplifier, the noise temperature was found to decrease almost linearly from 68 deg. K at room temperature to 21 deg. K at the temperature of liquid nitrogen. About 10 deg. K of this noise is believed to be contributed by the circuit. This excess noise temperature is of the order of that obtainable with present-day Masers operating at this frequency. Because of its simplicity, such a parametric amplifier may therefore become a competitor of the Maser in some system applications.

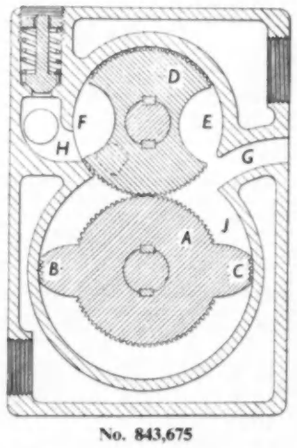
BRITISH PATENT SPECIFICATIONS

The dates printed are those of application and publication on completion. Copies of specifications may be obtained at the Patent Office Sales Branch, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each

COMPRESSORS

843,675. December 30, 1957.—ROTARY COMPRESSORS, Institut Francais du Petrole, des Carburants et Lubrifiants, 2, rue de Lubeck, Paris XVIe, France.

One of the simplest forms of rotary compressor according to the invention is shown in the drawing. This compressor comprises a central rotor *A* with two symmetrically positioned identical pistons *B* and *C* and rotatably mounted in a stator with passages for the circulation of coolant, such as water. Also rotatably mounted in the stator is a rotary abutment *D* with two symmetrically positioned identical recess *E* and *F*. The stator has an inlet passage *G* and an outlet passage *H* for gases. Opening off the outlet passage is a spring-loaded safety valve. Each of the rotors according to the invention is preferably provided with teeth around that part of its periphery which is not interrupted by pistons or recesses. These teeth are so dimensioned and arranged that those of the central rotor do not make contact with those of the rotary abutment(s), but co-operate with them to form a series of baffles which form an effective and frictionless gas seal between the central rotor and the rotary abutment(s). The central rotor being driven in the clockwise direction, movement of the piston *C* draws the gas through the inlet passage into the annular space *J* between the rotor and its housing. After engaging with the recess *F*, the piston *B* interrupts communication between the inlet passage and the space *J*, thus enclosing the gases previously drawn in by the piston *C*, these gases then occupying the part of the space contained between the two pistons. The further movement of the piston *B* draws further gas into the part of the space *J* between the wall of the abutment *D* and the piston *B* itself. From the point when the piston *C* completely engages the recess *E*, the gases enclosed between the two pistons begin to be compressed in the part of the space *J* between the piston *B* and the wall of the abutment *D* until the moment when the recess *F* causes this part



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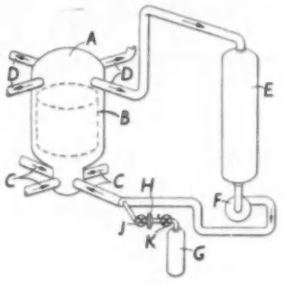
of the annular space to communicate with the outlet passage. The gases compressed between the piston *B* and the rotor are expelled through the outlet passage until the abutment *D* covers the opening of the outlet passage into the housing. Meanwhile, the piston *C* has drawn in behind it further gas to be compressed and when the piston *B* has completely engaged the recess *F*, the piston *C* begins to compress between itself and the wall of *D*, the gases previously drawn in by the piston *B*. The cycle is then repeated. As will be seen, the operation of this compressor is characterised by the fact that one of the pistons draws the gas to be compressed into the annular space, while the other piston compresses the gas previously introduced into the space; the rotary abutment serving not only to ensure sealing between the admission and compression zones but also as a distributor for the compressed gas. Alternative constructions are described in the specification.—*August* 10, 1960.

NUCLEAR POWER

843,871. January 26, 1959. GAS-COOLED NUCLEAR REACTORS, United Kingdom Atomic Energy Authority, London. (*Inventor: Everett Long.*)

According to this invention, a gas-cooled nuclear reactor has coupled to its coolant circuit via a valve a source of gas which is inert towards the materials in the coolant circuit, has a higher neutron absorption cross section than the coolant gas and is at a higher pressure than the coolant gas. On opening of the valve, inert gas is injected into the coolant circuit for reducing the reactivity of the reactor. The inert gas serves to control the reactivity by increasing the neutron absorption effect of the coolant. For example, a carbon-dioxide-cooled, graphite-moderated reactor may be shut down by the addition of argon, xenon or nitrogen to the carbon dioxide coolant. In view of the speed at which a gaseous coolant circulates the effect of the addition is very



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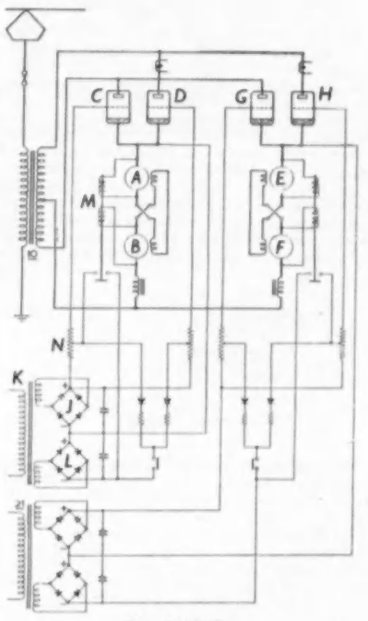
rapid. It so happens that the gases mentioned will also serve to suppress any fires which may occur in the reactor. The inert gas may be removed from the reactor without any after effect by purging the system with pure coolant. One way of carrying the invention is illustrated in the accompanying drawing showing a diagrammatic perspective view of one of the four coolant circuits of a Calder Hall graphite moderated nuclear reactor. Carbon dioxide at 120 lb per square inch circulates in a closed circuit consisting of a pressure vessel *A* containing the reactor core *B* and having inlet ducts *C* and outlet ducts *D* and a heat exchanger *E* and circulator *F* in ducting between each inlet and outlet duct. Each of the four inlet ducts has coupled to it a supply *G* of nitrogen at 1000 lb per square inch. The coupling between the supply of nitrogen and the respective inlet duct is made first via a normally closed power-operated valve with manual standby facilities, then via a frangible diaphragm *H* and thence via a normally open valve *J*. A very small leak path or bleed to atmosphere is provided between the valve *K* a..d the diaphragm so that any leakage through the valve *K* does not cause the diaphragm to burst. The leak is small enough to prevent undue escape of nitrogen when the valve is opened. The normally open valve *J* is provided for isolation of the nitrogen supply. Opening of valve *K* releases nitrogen into the coolant circuit in sufficient quantity to shut down the reactor.

The volume of nitrogen available from the four supplies is in excess of about 1¼ per cent of the total volume of carbon dioxide in the coolant circuit, this figure being considered to be approximately the minimum necessary to effect shut-down.—*August* 10, 1960.

ELECTRIC TRACTION

843,767. April 17, 1956.—CONTROL SYSTEM FOR ELECTRICALLY PROPELLED VEHICLES, The English Electric Company, Ltd., Queens House, 28 Kingsway, London, W.C.2. (*Inventor: Henry Bolton Calverley.*)

This invention relates to electrically propelled vehicles having at least two d.c. driving motors supplied from an external a.c. source via full wave rectifying means on the vehicle. In such a vehicle means responsive to, or dependent on, the occurrence of wheel slip on any individual motor are arranged automatically to convert the supply to at least the slipping motor from full wave to half wave rectification. A preferred form of the invention applied to an a.c. rectifier locomotive is shown in the drawing, where traction motors *A*, *B* are supplied through rectifiers *C*, *D*, while motors *E*, *F* are supplied similarly through rectifiers *G*, *H*. The negative return for each group of motors is taken to the centre tap of the transformer secondary winding so that full wave rectification is obtained. The grids of the rectifiers *C* and *D* are normally maintained at a positive potential with respect to the corresponding cathode by connecting each via tapped resistors respectively to the positive terminal of a full wave rectifier bridge



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J, the cathodes of the rectifiers being connected to the negative terminal of the bridge, which is supplied from one secondary winding of an auxiliary transformer *K*. A further secondary winding on this transformer supplies a full wave rectifier bridge *L*, the positive terminal of this bridge being connected to the negative terminal of bridge *J*. Associated with motor group *A*, *B* is a wheel slip relay *M* having two coils, each of which is connected across the armature of one of the two motors. Under conditions of no wheel slip on these two motors, the two coils are energised substantially equally and opposite and the contacts of the relay are maintained open. If, on the other hand, either of these two motors should slip, the balance of the two relay coils will be upset and the relay will close its contacts to connect the tap on the resistor *N* directly to the negative terminal of the rectifier bridge *L* and thus make the control grid of rectifier *C* negative with respect to its cathode and so render this rectifier non-conducting on all subsequent cycles. As a result, motor group *A*, *B* will thereafter operate only on half wave rectification and there will be an immediate and considerable reduction in the current drawn by the two motors. This reduction in current allows the slipping wheel to regain adhesion of the rail, and when adhesion is regained the voltage balance will be restored and the relay will open its contacts and thereby restore full wave rectification. A similar arrangement applies to motors *E*, *F* and their rectifiers *G*, *H*—*August* 10, 1960.

MINING MACHINES

844,091. March 19, 1958.—COAL-CUTTING AND LIKE MINING MACHINES, Gebr. Eickhoff, Maschinenfabrik U Eisengiesserei m.b.H., Bochum, Germany.

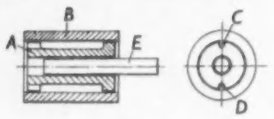
According to the invention a coal-cutting machine has a drive mechanism for advancing which comprises a variable speed a.c. motor which is controlled to provide a continuously variable speed of advance. The motor drives a haulage device independently of the power source for the cutting tools of the machine. A suitable motor is the three-phase commutator shunt-type machine the speed of which can be varied continuously and without loss within certain limits. The motor is used in place of the known hydraulic transmission mechanism and can be located within the housing of the winch which it normally drives through speed reduction gearing. The speed of this motor is controlled by moving its brush-connecting yoke to provide a rotor commutator voltage for controlling the stator voltage. The yoke may be adjusted by a handwheel on the fixed structure of the winch which directly actuates the yoke. In an alternative arrangement, the handwheel is arranged to control a separate adjusting motor mounted on

the three-phase motor. When such a setting motor is used, the speed of advance of the cutting machine may be controlled automatically in accordance with the load on the main driving motor or by a remote-control device.—*August* 10, 1960.

TELECOMMUNICATIONS

44,399. June 7, 1957.—INDUCTANCE COIL, Standard Telephones and Cables, Ltd., Connaught House, 63, Aldwych, London, W.C.2.

In known tuning arrangements for inductance coils with ferromagnetic cores, fine adjustment of the inductance is difficult to achieve. Furthermore it is difficult to mount the separate parts of the core so that they are in exact fixed position which does not vary as a result of vibration or temperature changes. The inductance coil according to the present invention is largely free from these drawbacks and has a very favourable space factor. Its construction is shown in the drawings, wherein the core consists of a flanged bobbin *A* of ferromagnetic material and an outer sleeve *B* also of ferromagnetic material fitting closely over the flanges of the bobbin. The coil (not shown) is wound on the bobbin *A* either directly



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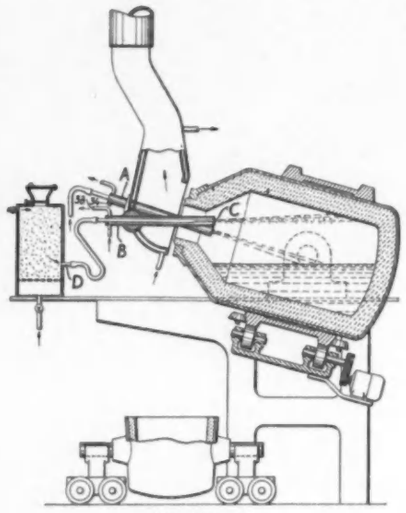
or with the interposition of a coating on the bobbin of insulating material. The winding is thus enclosed in the space between the bobbin and the outer sleeve. Apertures *C* and *D* are formed in one of the flanges of the bobbin and lead-in wires for the coil winding pass through these apertures. A tuning core *E* of ferromagnetic material of higher permeability than that of the bobbin is inserted in the bore of the bobbin and is movable therein for adjustment of the inductance. An inductance coil of the construction shown has been constructed having a winding of over a hundred turns of wire composed of five strands of 0·05mm litz wire and with an inductance variable from 200 to 500 micro-Henries but occupying a volume of only one-third of a cubic centimetre. The specification also illustrates a band pass filter unit incorporating twelve coils of this form. Such an assembly may be cast in resin leaving free the spaces around the tuning rods *E* and after the fine adjustment of tuning by means of these rods, resin may be cast around the rods to make the tuning insensitive to external influences.—*August* 10, 1960.

FURNACES

843,714. January 28, 1958.—PROTECTING THE LINING OF ROTARY FURNACES FOR TREATING MOLTEN METAL, Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

In metallurgical melting and refining processes it is often difficult to attain a sufficient durability of the furnace lining. This is particularly true for refining processes where oxygen or air enriched with oxygen is blown on to the surface of or into the melt in order to bring about a desired oxidation of certain constituents of the metal, and at the same time to generate the necessary heat for the process. Normally this heat generation is so strong that it is necessary to perform additions of some material during the process in order to counteract too high temperatures. According to the invention the lining of a rotary furnace is protected when treating a metal melt by an oxygen-rich gas by introducing into the furnace a stream of cooling agent separate from the gas so as substantially to cut off radiation of heat from the surface of the melt where the gas comes into reactive contact with the melt. The cooling agent is a granular solid suspended in a gas and it is preferably injected into the furnace so as to impinge against the wall. The gaseous component of the cooling agent may advantageously be steam or carbon dioxide. The metal may be iron, steel and alloys, in which case the solid component of the cooling agent is advantageously selected from limestone, quick lime and iron ore. The solid agent injected in the manner described above causes a substantial cutting off of heat radiation in that the solid particles in the furnace atmosphere absorb such heat and to a minor degree reflect radiated heat back against the melt. It also tends to cause the gases escaping from the hottest region to deviate from a direction towards the furnace wall. Where the solid agent impinges against the furnace wall it forms a protective layer on the part of the wall which would otherwise run the risk of becoming superheated. The drawing illustrates a rotary furnace equipped for carrying out the method. The furnace has a single opening at the centre of one end wall and an exhaust gas hood is located with a clearance of about 1 decimetre in front of this opening, when the furnace is in position for the heat-treatment at an inclination of, for instance, 15 deg. to 20 deg. The hood is provided with a water cooling jacket and mounted in it are two (copper) tuyeres, one ordinary blast tuyere *A* and one tuyere *B* for the cooling means. Both are water-cooled and gas rich in oxygen is supplied to the tuyere *A* through flexible hose. The tuyere *B* has



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an inner pipe *C* which is connected to a flexible pipe secured to the outlet pipe *D* of a lime suspending apparatus. This apparatus consists of a container having at its top a lime feeding hopper and at its bottom a grid. Below the grid is a pressure gas inlet pipe for the supply of gas for fluidising the lime. Another pressure gas inlet pipe opens into the container at a suitable level above the grid for supplying feeding gas, if required, in addition to that supplied through the lower pipe. The necessary quantity of pressure gas should only amount to a few (less than 10) cubic metres per ton of introduced powder, so that the quantity of gas that leaves the furnace will be increased only a little as a result of the supply. If it is desired to avoid the introduction of oxygen and nitrogen into the furnace space by this operation it is possible to use other gases than air, e.g. carbon dioxide. According to a preferred embodiment at least part of the necessary lime is injected on to the wall of the furnace at that part which is most exposed to attack. In this manner an effective shielding is obtained and at the same time lime, which may have adhered to the wall, protects it from chemical attack from slag and insulates it against heat transfer. Thus, the useful life of the furnace lining may be increased considerably, and, furthermore, the supply of the lime is performed in a manner which is highly convenient for the process. It is also possible to add finely ground iron ore which consumes heat by chemical reaction. The grain size of the solid component of the cooling agent should be less than 10 millimetres and preferably less than 5 millimetres, but should exceed 0·5 millimetres. A certain valuable effect is obtained by the shielding action of the introduced cooling agent while passing through the gas space in the furnace and by spreading the jet of cooling agent an appreciable reduction of the heat radiation on to the furnace wall may be attained. It has been found that an especially good effect is obtained by means of the present cooling method where the rotational speed of the furnace is rather high, exceeding approximately 5 r.p.m. The quantity of cooling agent which should be added in each case may easily be determined experimentally, but as a rule it is possible to calculate the required quantity with reasonable accuracy.—*August* 10, 1960.

ELECTRICAL ENGINEERING

843,830. March 26, 1957.—ELECTRICAL POSITIONAL CONTROL APPARATUS, The British Thomson-Houston Company, Ltd., Crown House, Aldwych, London, W.C.2. (*Inventor : Leslie Carter Ludbrook.*)

The electrical positional control apparatus described in this specification is intended to provide an arrangement giving higher torque than a selsyn system but not requiring commutators for d.c. excitation. According to the invention the apparatus comprises an a.c. generator having a stator with a plurality of phase windings and a rotor adapted to be supplied with a single-phase a.c. voltage ; also a motor having a stator with a number of phase windings equal to that of the generator stator and having a permanent magnet rotor or a d.c. excited rotor. The output of each winding of the generator stator is rectified and the rectified outputs are passed through a reversing switch to supply a stator winding of the motor, each reversing switch being controlled by the rotation of the rotor of the generator. The arrangement is such that each stator winding of the motor is thus supplied with a variable voltage corresponding instantaneously in magnitude and polarity with the angular position of the rotor of the generator relative to the associated stator winding. These voltages differ in phase from one another so as to tend to cause the rotor of the motor to rotate in accordance with the rotation of the rotor of the generator regulator. The motor may, for example, be a synchronous motor and preferably with a permanent magnet rotor, or it could be a repulsion motor or a motor following a step-by-step movement. It will be appreciated that such an arrangement provides a positional control having an appreciable torque and is applicable *inter alia* to hoists such as hoists for raising and lowering the control rods of a nuclear reactor.—*August* 10, 1960.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, Sept. 2.—LIVERPOOL AND DISTRICT BRANCH : Industrial Development Centre, M.A.N.W.E.B., Paradise Street, Liverpool, 1, Chairman's Address, L. Harper, 7.30 p.m.

Mon., Sept. 5.—ESSEX BRANCH : The Angel Hotel, Broadway, Ilford, Essex, "Domestic Electrical Accidents," S. J. Emerson, 8.15 p.m. ★ LEEDS BRANCH : Great Northern Hotel, Leeds, "Dry Fluid Centrifugal Power Couplings," A. O. Hunt, 7.30 p.m. ★ SHEFFIELD BRANCH : Royal Victoria Hotel, Sheffield, Chairman's Address, R. Peacock, 7.30 p.m.

Tues., Sept. 6.—W. LONDON BRANCH : Windsor Castle Hotel, 134, King Street, Hammersmith, W.6, "Panelec Warming System," 7.45 p.m. ★ READING AND DISTRICTS BRANCH : "Marquis of Lorne," Friar Street, Reading, "Testing of New Appliances," H. F. Watson, 7.30 p.m.

Wed., Sept. 7.—HALIFAX BRANCH : The Crown Hotel, Horton Street, Halifax, "Miniature Circuit Breakers," H. E. Banks, 7.45 p.m. ★ N. LONDON BRANCH : Civic Centre, Town Hall, Wood Green, N.22, "A.C. Variable Speed Drives," P. H. Jackson, 8 p.m. ★ MANCHESTER BRANCH : Engineers' Club, Albert, Square, Manchester, "Jointing Plastic Cables," 7.15 p.m. ★ NOTTINGHAM BRANCH : Mechanics Institution, Trinity Square, Nottingham, Chairman's Address, 7.30 p.m. ★ PRESTON BRANCH : R.A.F.A. Club, East View, Preston, "Electrical Floor-Warming," M. Bolser, 7.30 p.m.

Thurs., Sept. 8.—BRADFORD AND DISTRICT BRANCH : College of Technology, Great Horton Road, Bradford, "The Kariba Dam Project," G. Lyon, 7.30 p.m. ★ BRIGHTON, HOVE AND DISTRICT BRANCH : New Imperial Hotel, 1st Avenue, Hove, Sussex, "Cable Jointing," J. Kernaghan, 7.30 p.m.

BIRMINGHAM SCIENCE MUSEUM

Thurs., Sept. 29.—Museum of Science and Industry, Newhall Street, Birmingham, 3, "Live Steam Operation of Five Engines," evening until 9 p.m., additional to regular "Steam Week-ends."

BRITISH INTERPLANETARY SOCIETY

Mon., Sept. 12.—Lancaster Room, Caxton Hall, London, S.W.1, "Spaceflight—Hints, Pitfalls and Problems," L. J. Carter, 7 p.m.

Tues., Sept. 13.—Lancaster Room, Caxton Hall, London, S.W.1, "Special Points in Lectures to Schools," N. H. Langton, "Preparing a Technical Paper," L. R. Shepherd, 7 p.m.

INSTITUTION OF PLANT ENGINEERS

Tues., Sept. 6.—LONDON BRANCH : Royal Society of Arts, John Adam Street, Adelphi, Strand, London, W.C.2, "Pneumatic Transfer Machinery and Circuitry," D. C. Evans, 7 p.m.

Wed., Sept. 7.—EDINBURGH BRANCH : 25, Charlotte Square, Edinburgh, "The History of Boilers," W. Renton, and "An Engineer and the Carpet Industry," W. Geekie, 7 p.m. ★ LEICESTER BRANCH : Saracen's Head Hotel, Leicester, Film and Discussion "On Schedule," F. W. L. Heathcote, 7 p.m.

Thurs., Sept. 8.—GLASGOW BRANCH : Scottish Building Centre, 425, Sauchiehall Street, Glasgow, "Factory Fire Alarm Systems," W. Roby and R. S. C. Dougall, 7.15 p.m. ★ NORTH EAST BRANCH : Roadway House, Oxford Street, Newcastle upon Tyne, 1, "Electrical Power Distribution," J. E. Finn, 7 p.m.

Wed., Sept. 14.—WESTERN BRANCH : Royal Clarence Hotel, Exeter, "Motorway," film and talk on the construction of the M.1, 7 p.m.

Thurs., Sept. 15.—BLACKBURN BRANCH : Castle Hotel, Blackburn, "New Developments in Fuel and Power Technology," M. W. Thring, 7.30 p.m.

INSTITUTE OF PETROLEUM

Wed., Sept. 7.—61, New Cavendish Street, London, W.1, "The Part Played by the Preparational Stage in Determining Lead Anti-Knock Effectiveness," D. Downs, S. T. Griffiths and and R. W. Wheeler, 5.30 p.m.

NINTH INTERNATIONAL CONGRESS OF PHOTOGRAMMETRY

Sept., 1960.—To be held at the University of London under the auspices of the International Society for Photogrammetry ; Sept. 5 to 16, technical sessions ; Sept. 6 to 16, exhibitions ; Sept. 17 to 21, technical tours.

SOCIETY OF CHEMICAL INDUSTRY

Wed. to Fri., Sept. 21 *to* 23.—PLASTICS AND POLYMER GROUP : William Beveridge Hall, Senate House, University of London, W.C.1, Symposium on "High Temperature Resistance and Thermal Degradation of Polymers."

SOCIETY FOR WATER TREATMENT AND EXAMINATION

Wed. to Fri., Sept. 14 *to* 16.—St. Peter's Hall, Oxford, Autumn Meeting, 1960.

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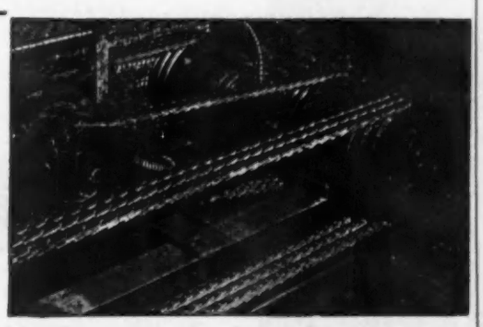

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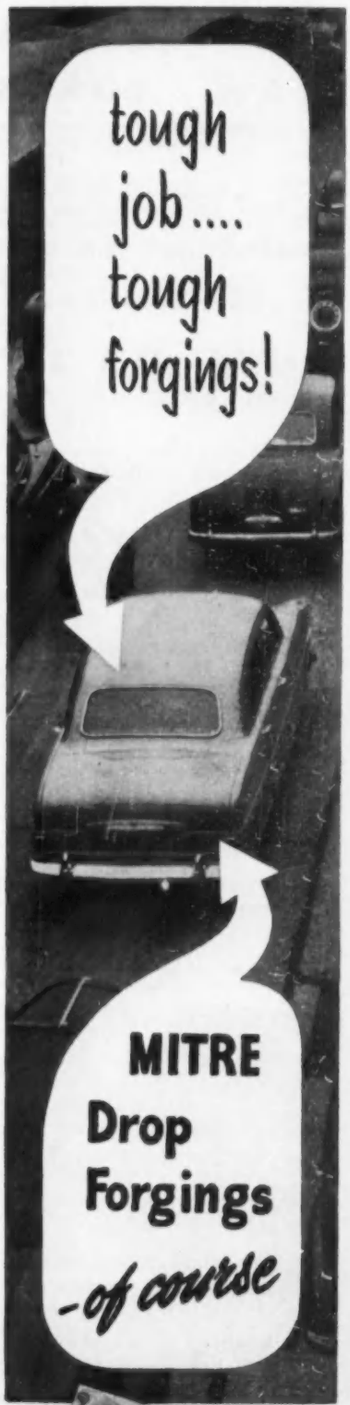

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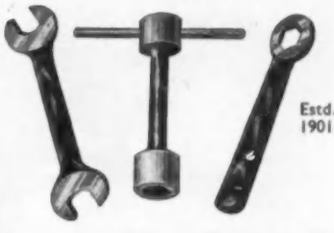

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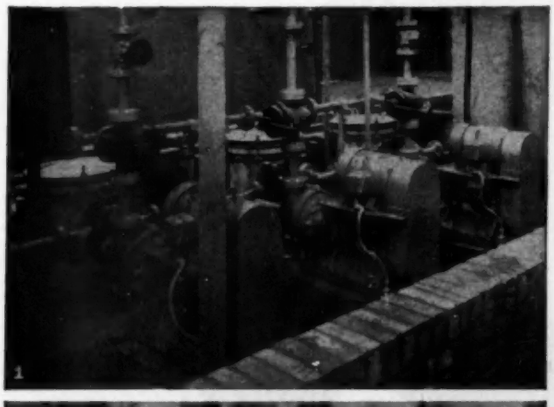

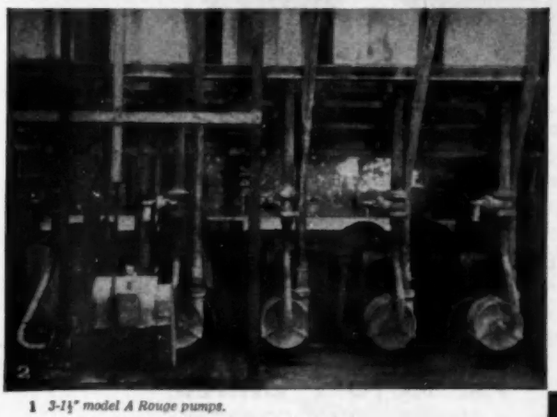

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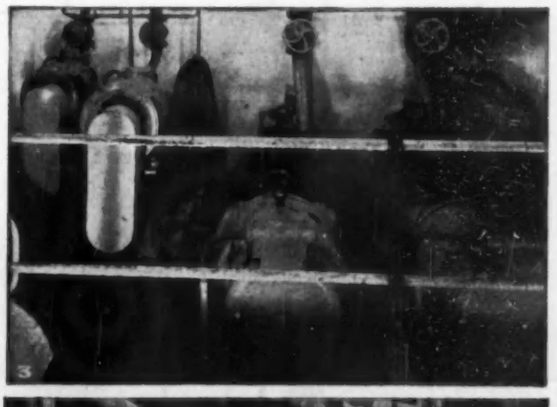

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P.58

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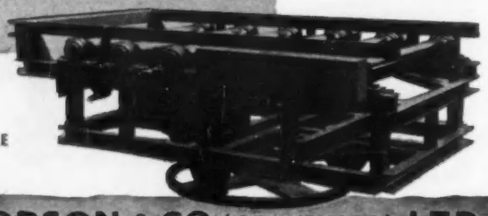

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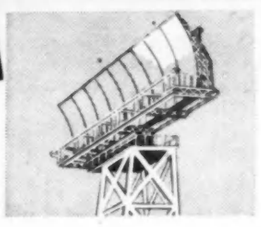

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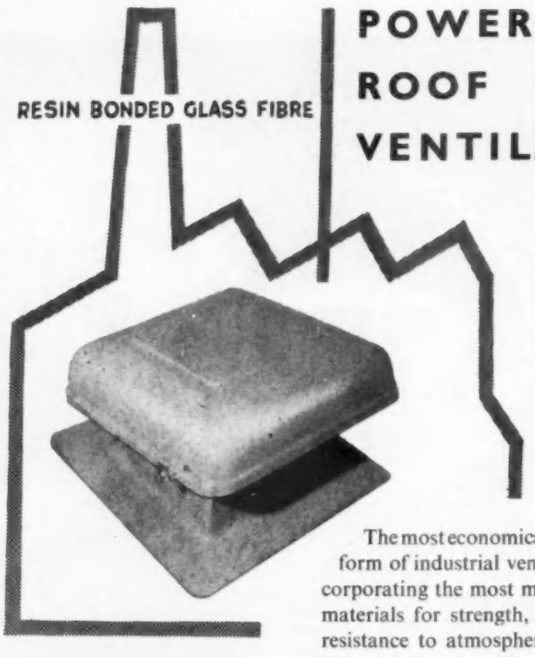

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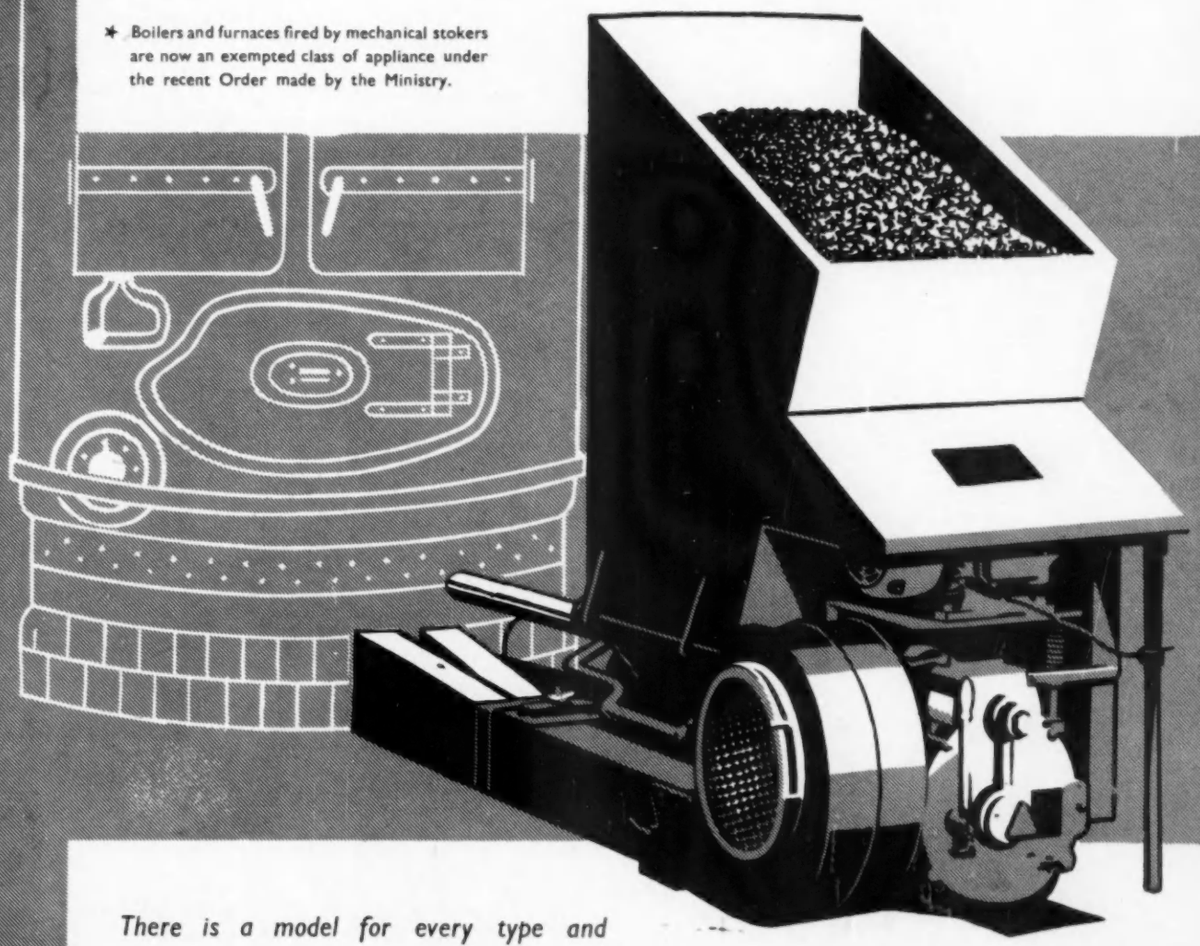

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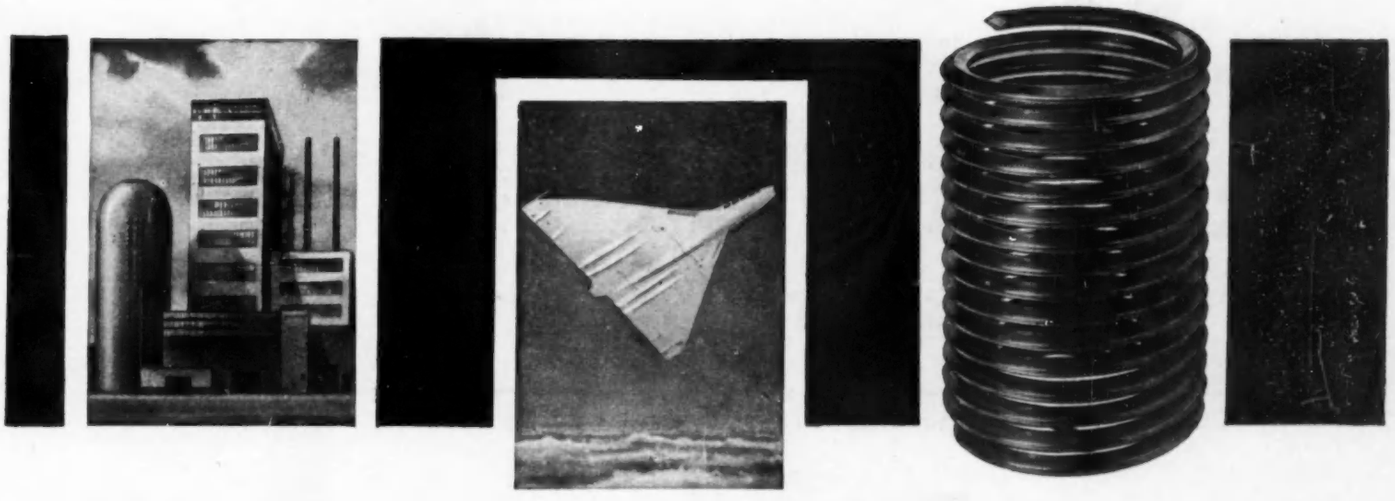

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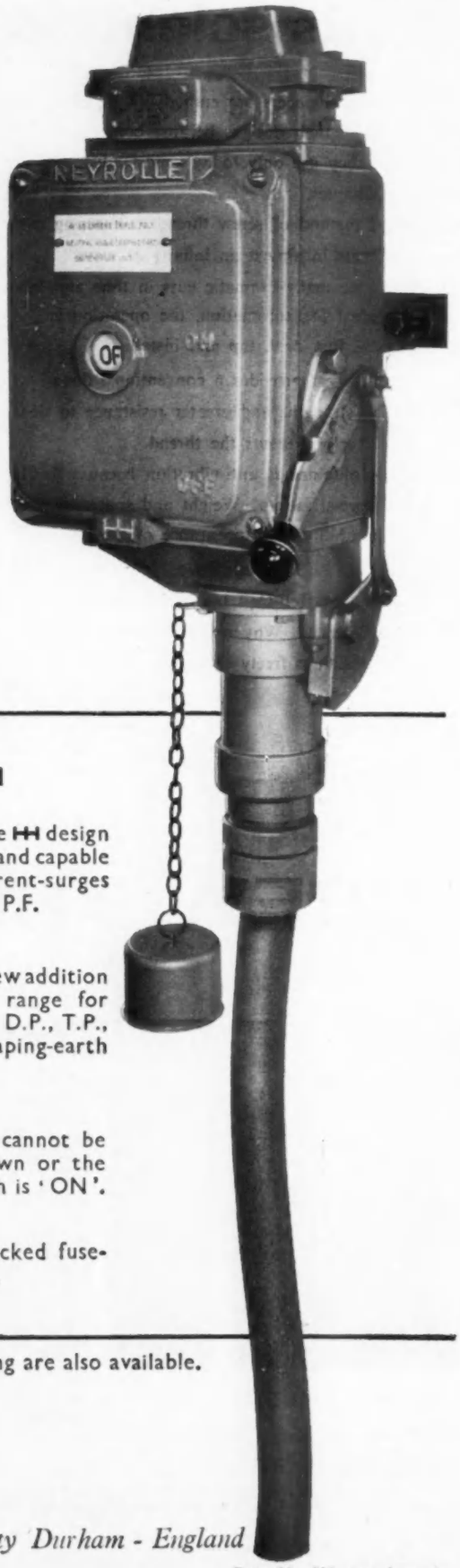

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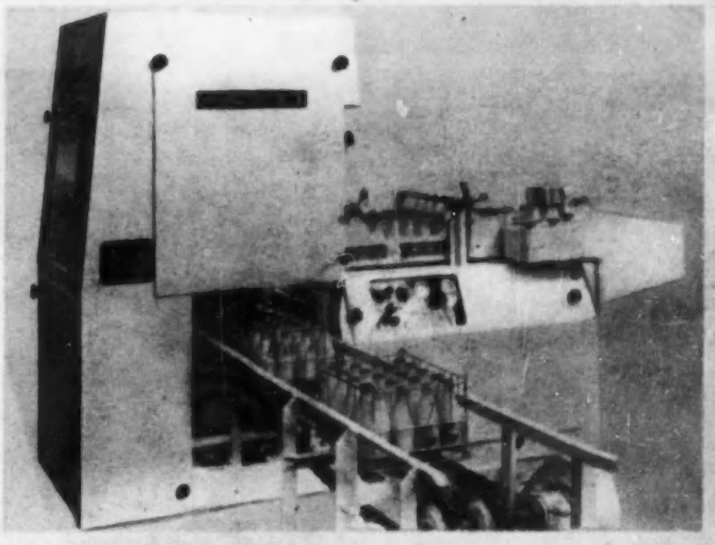

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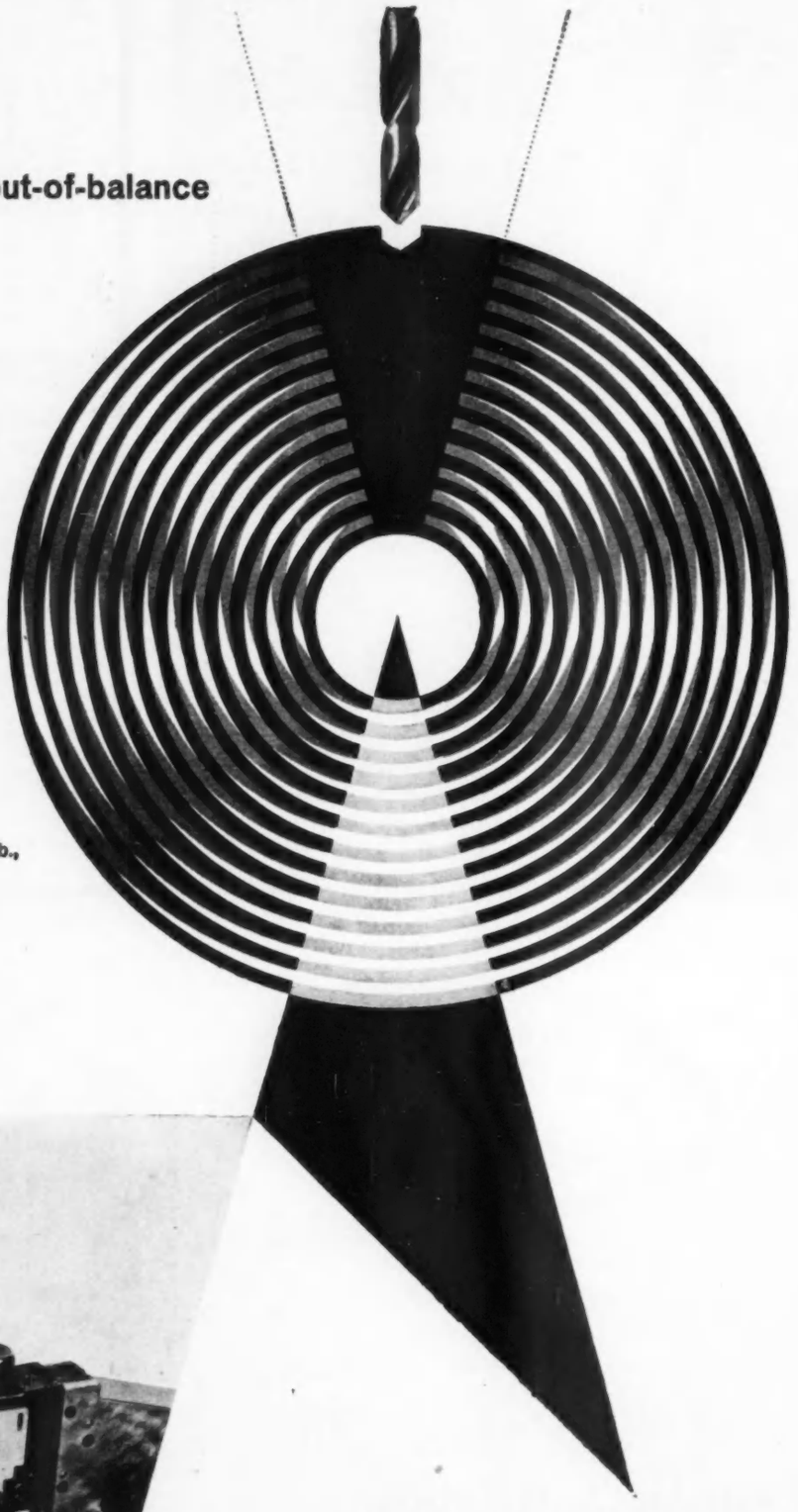

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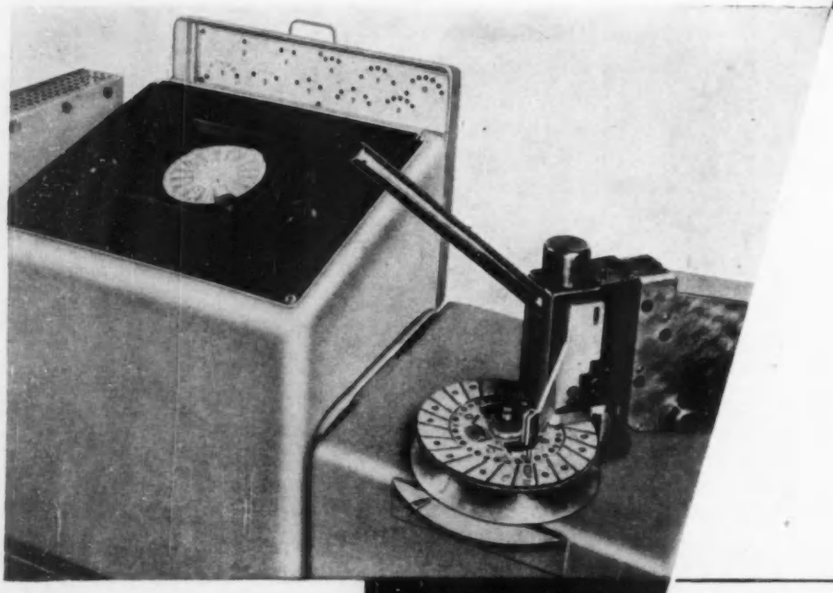

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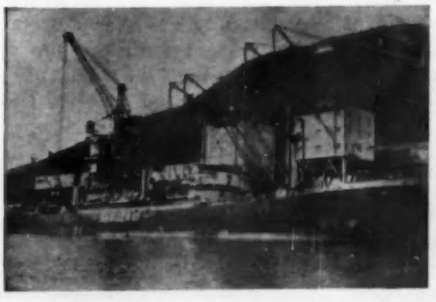

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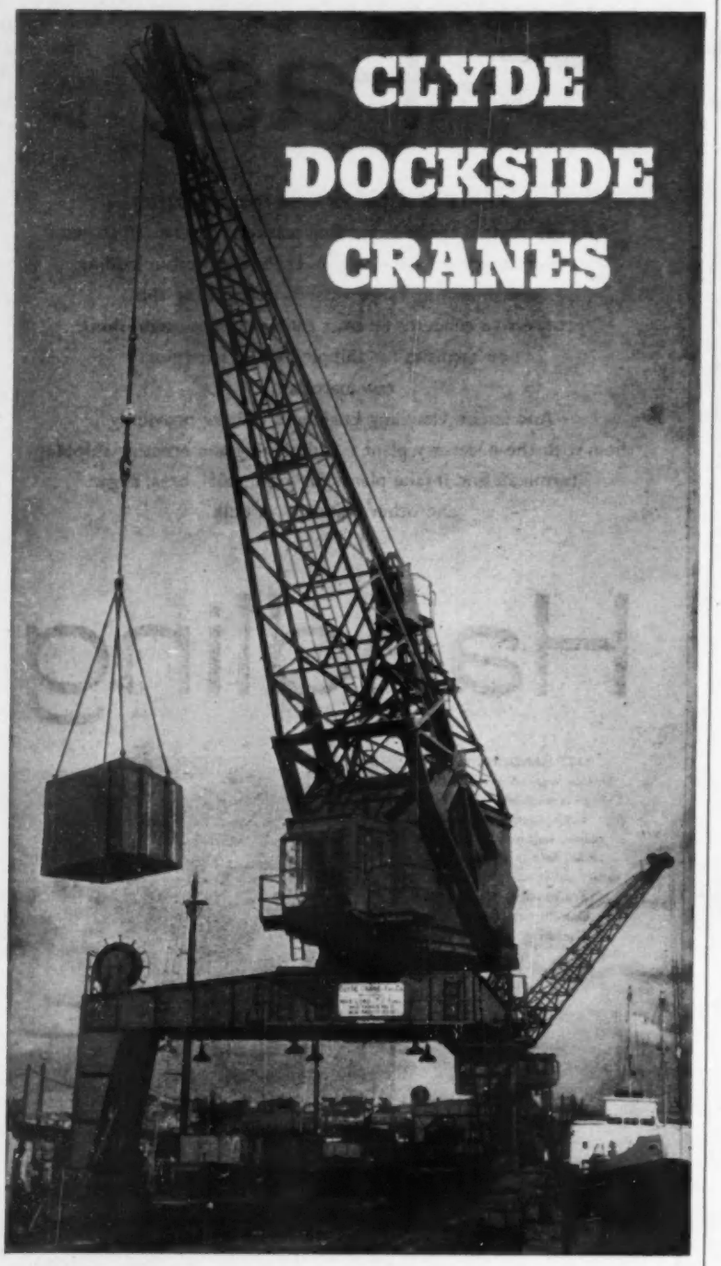

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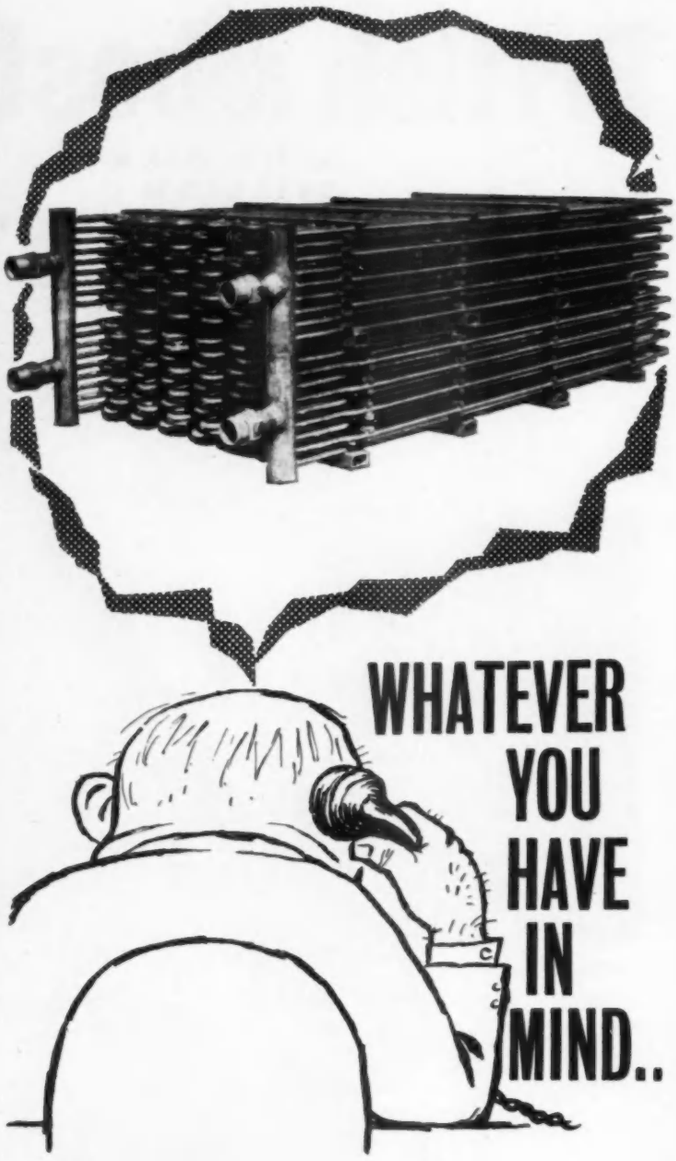

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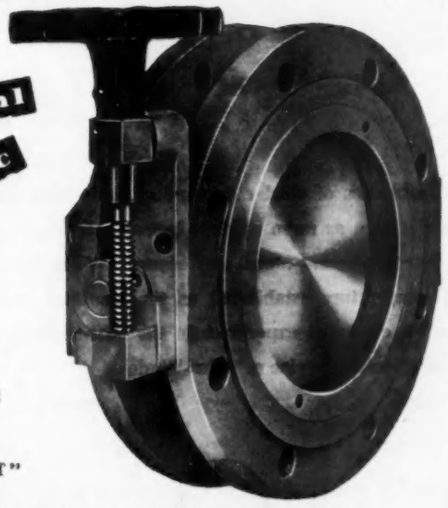

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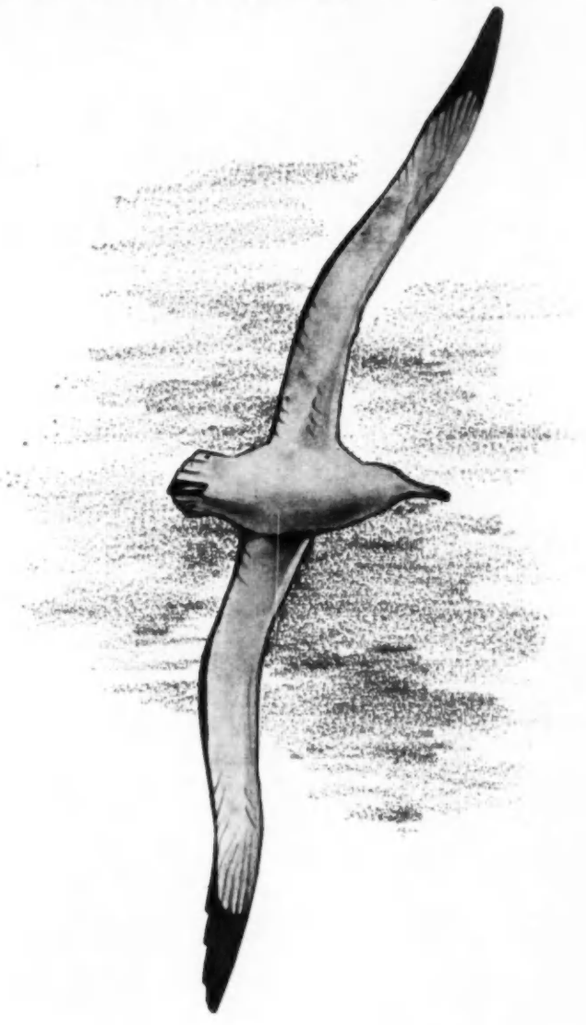

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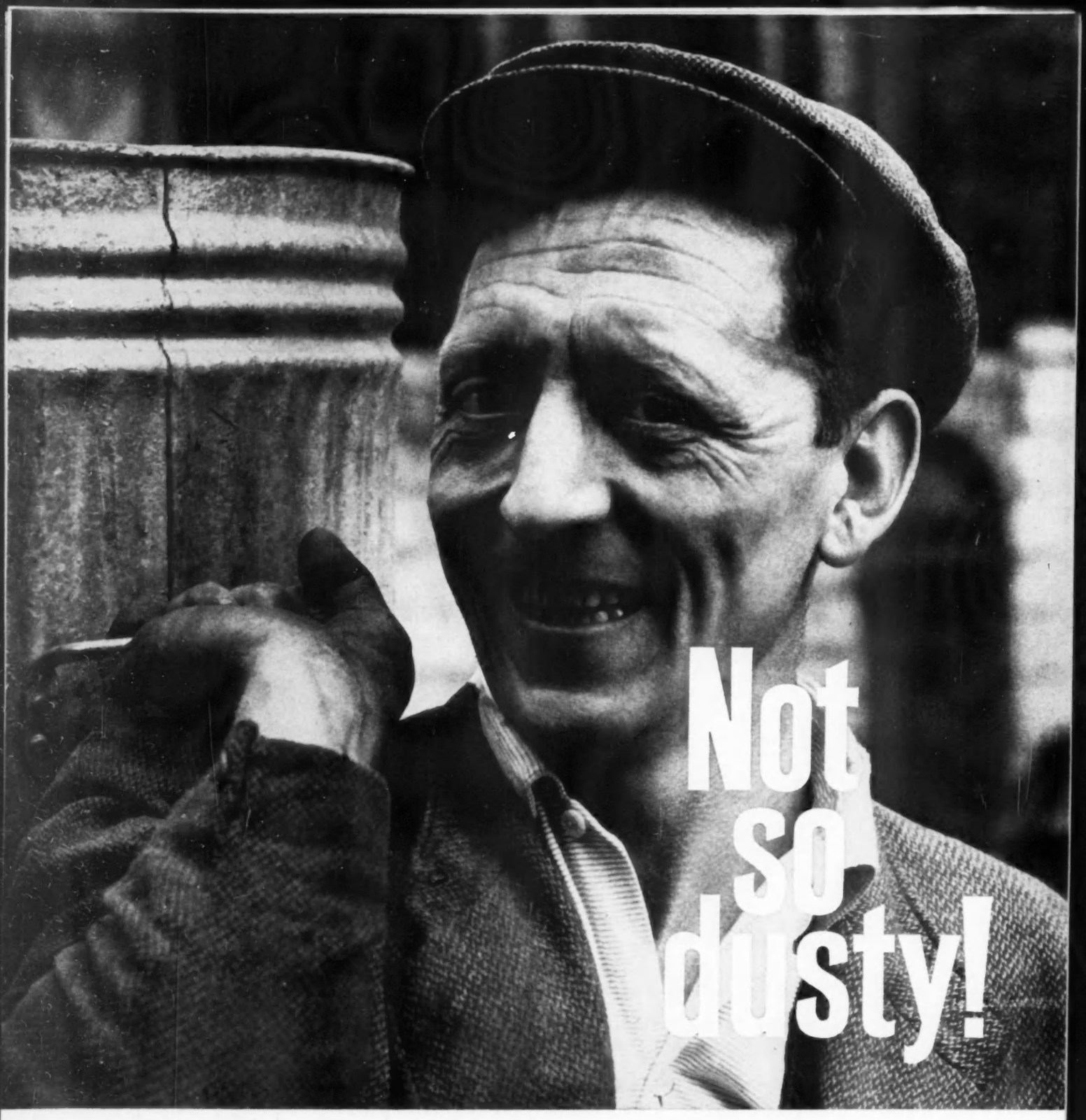

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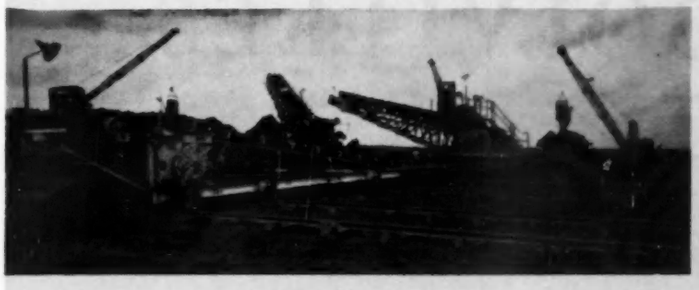

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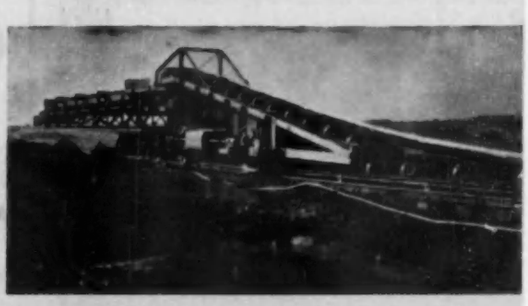

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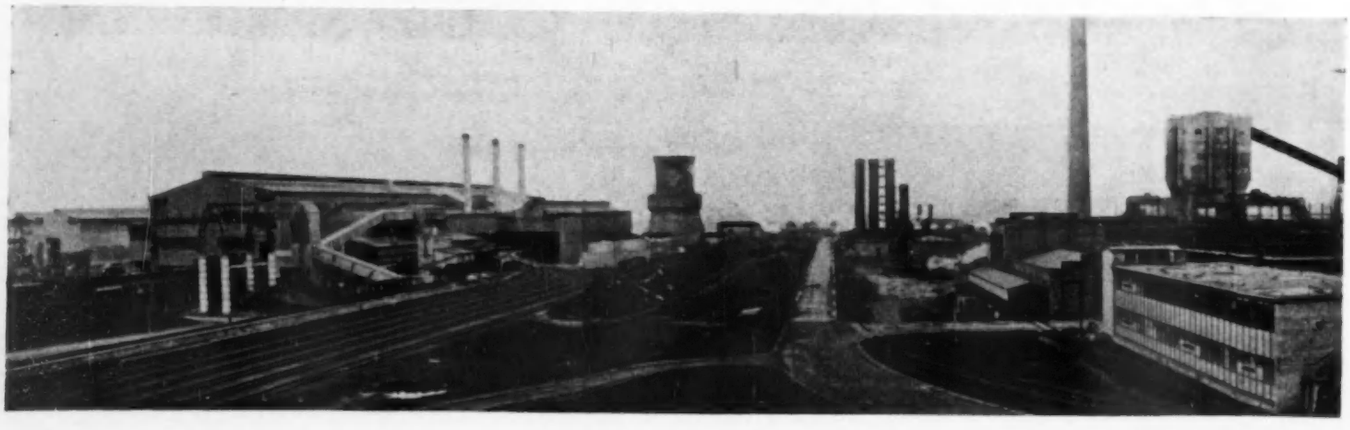

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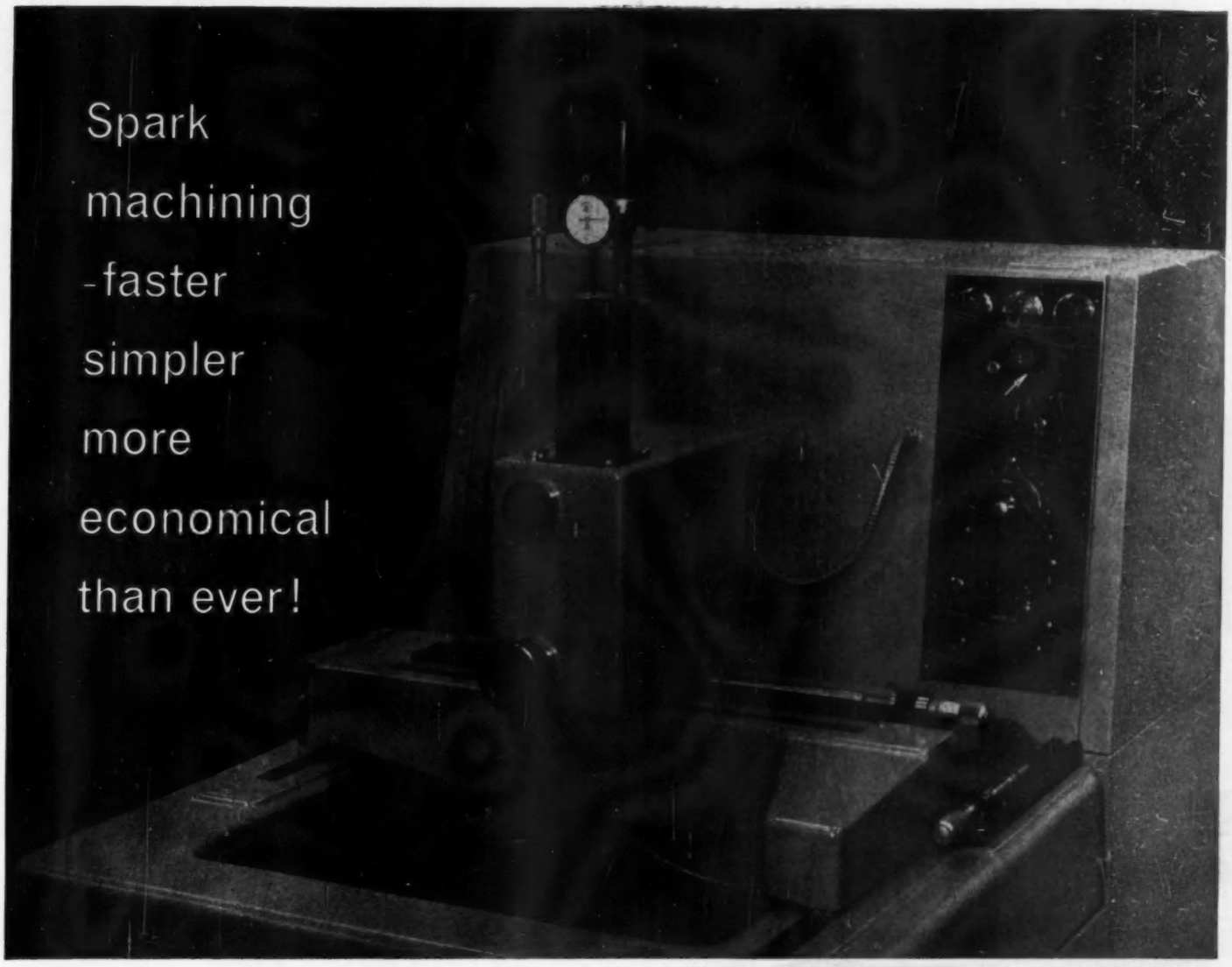

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GKN spark machine

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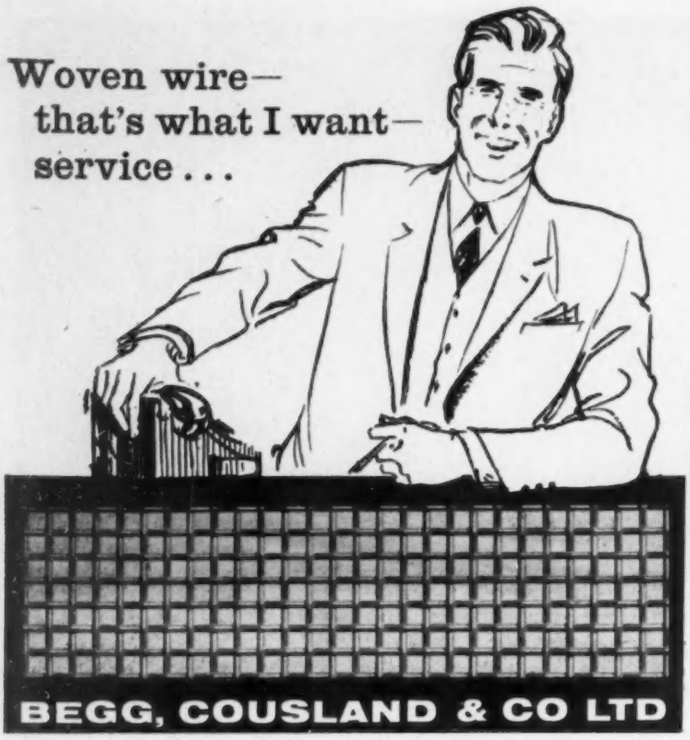

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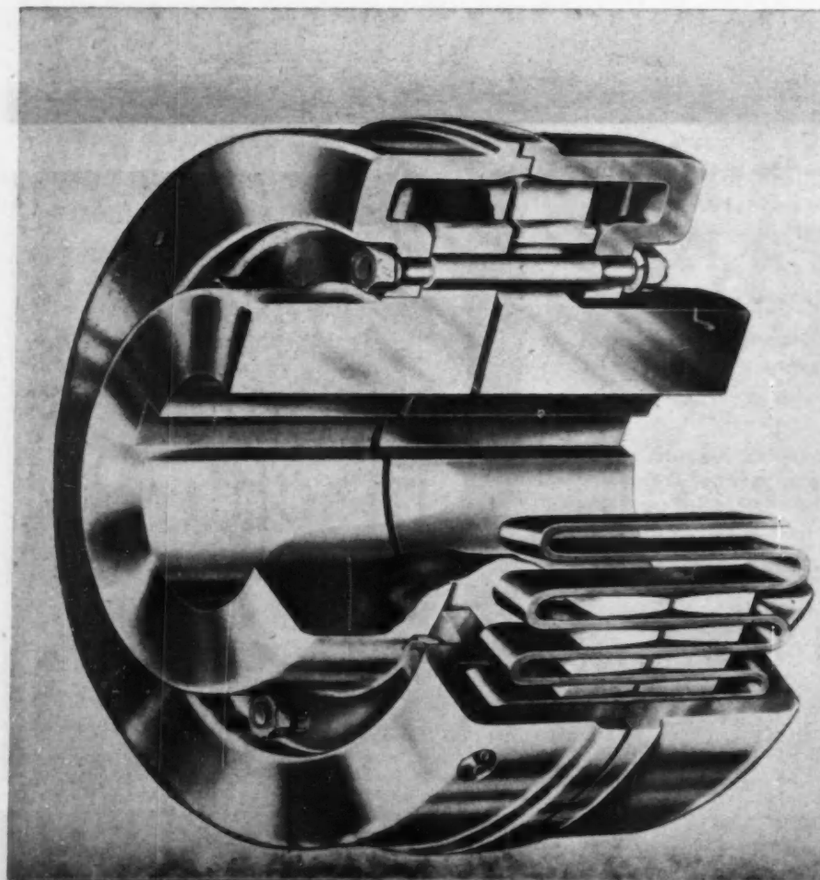

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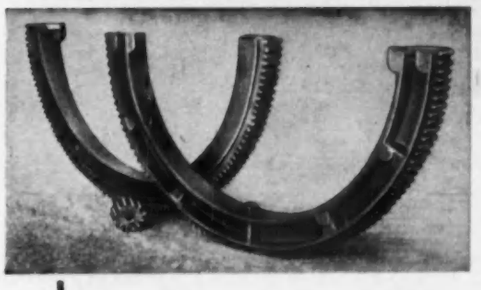

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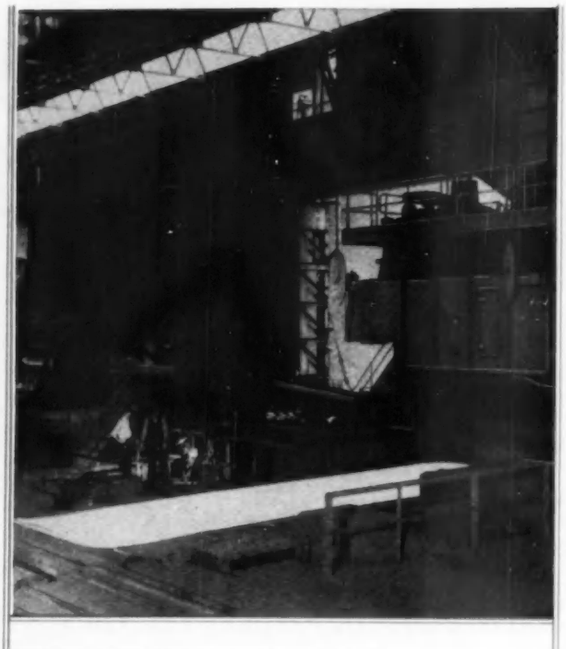

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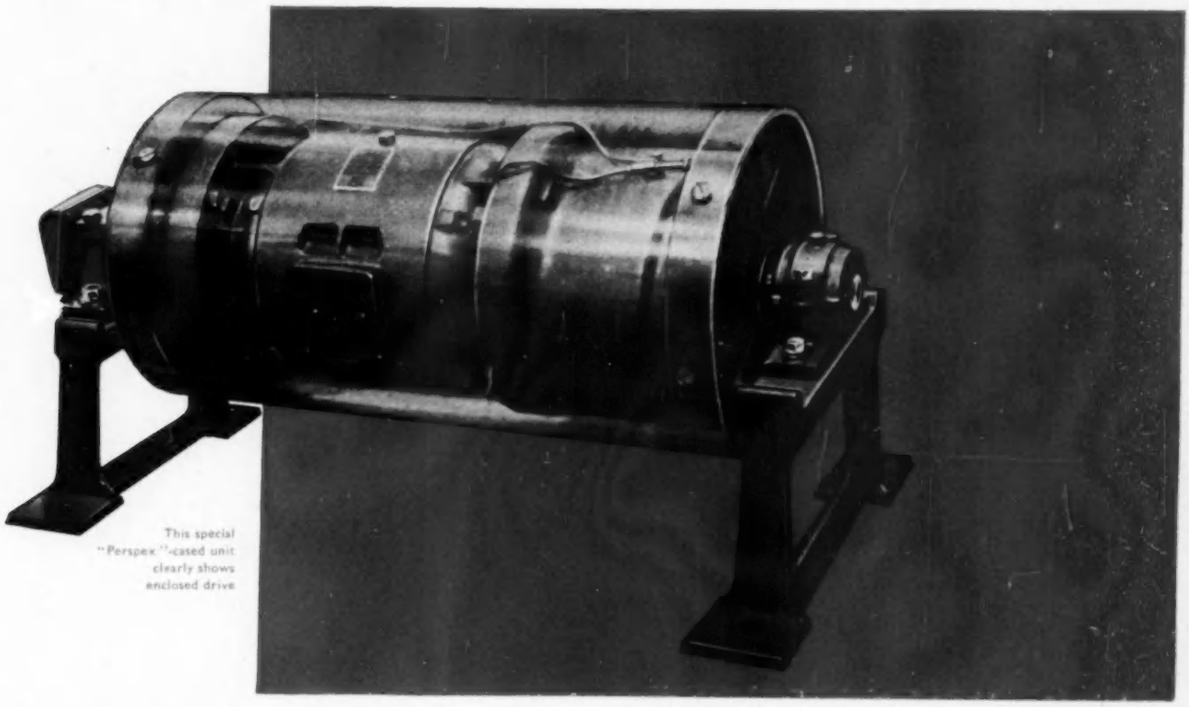

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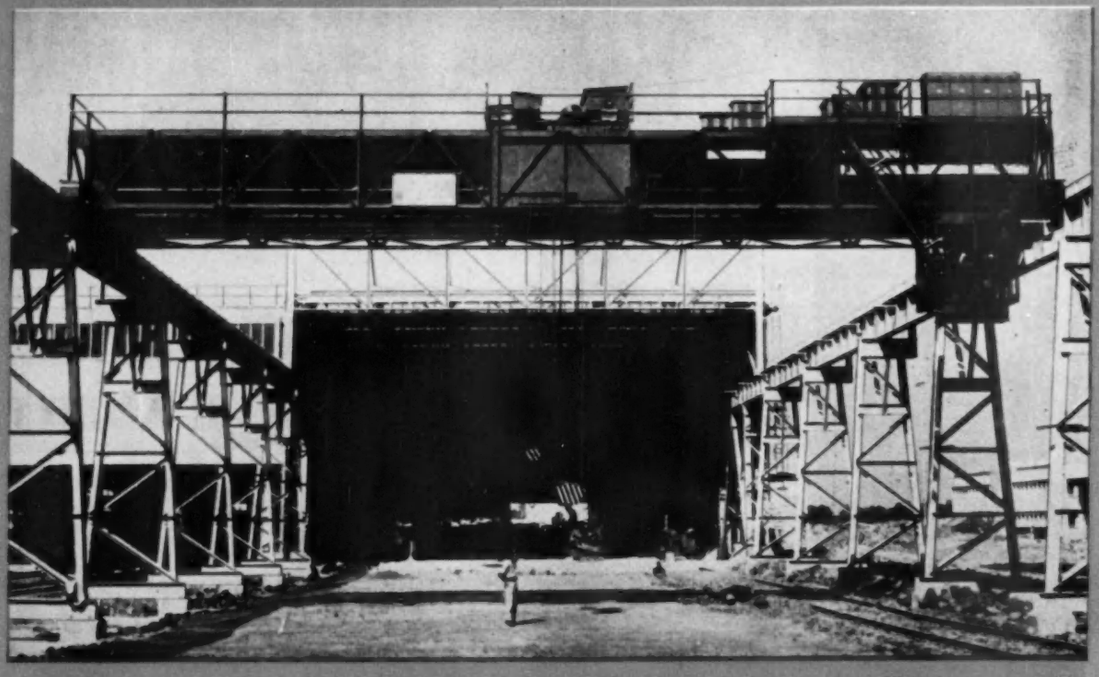

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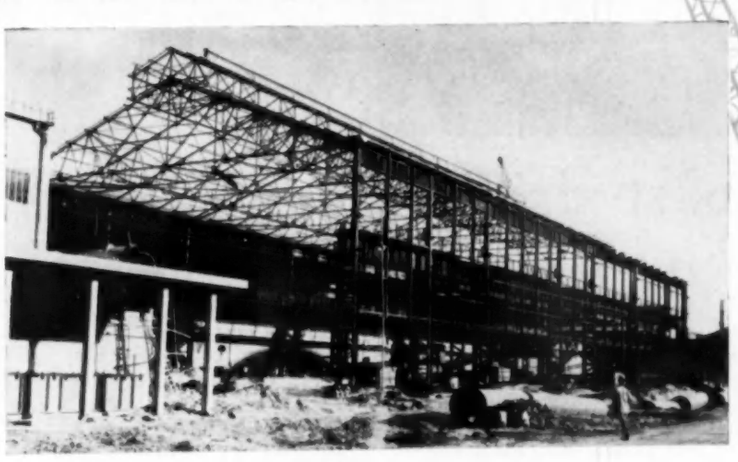
Steelwork at DURGAPUR



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do you know

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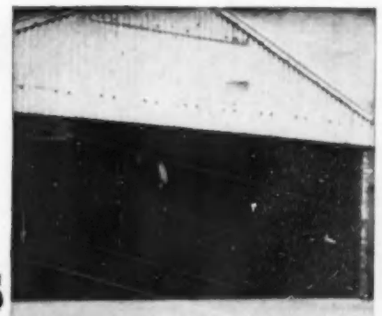
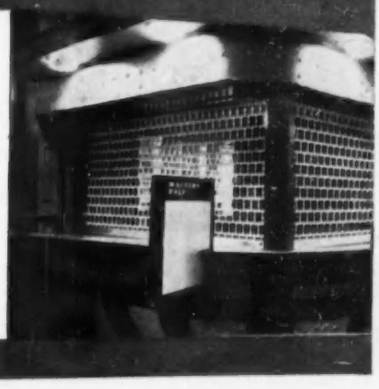
roller shutters



sliding shutter doors

rolling grilles



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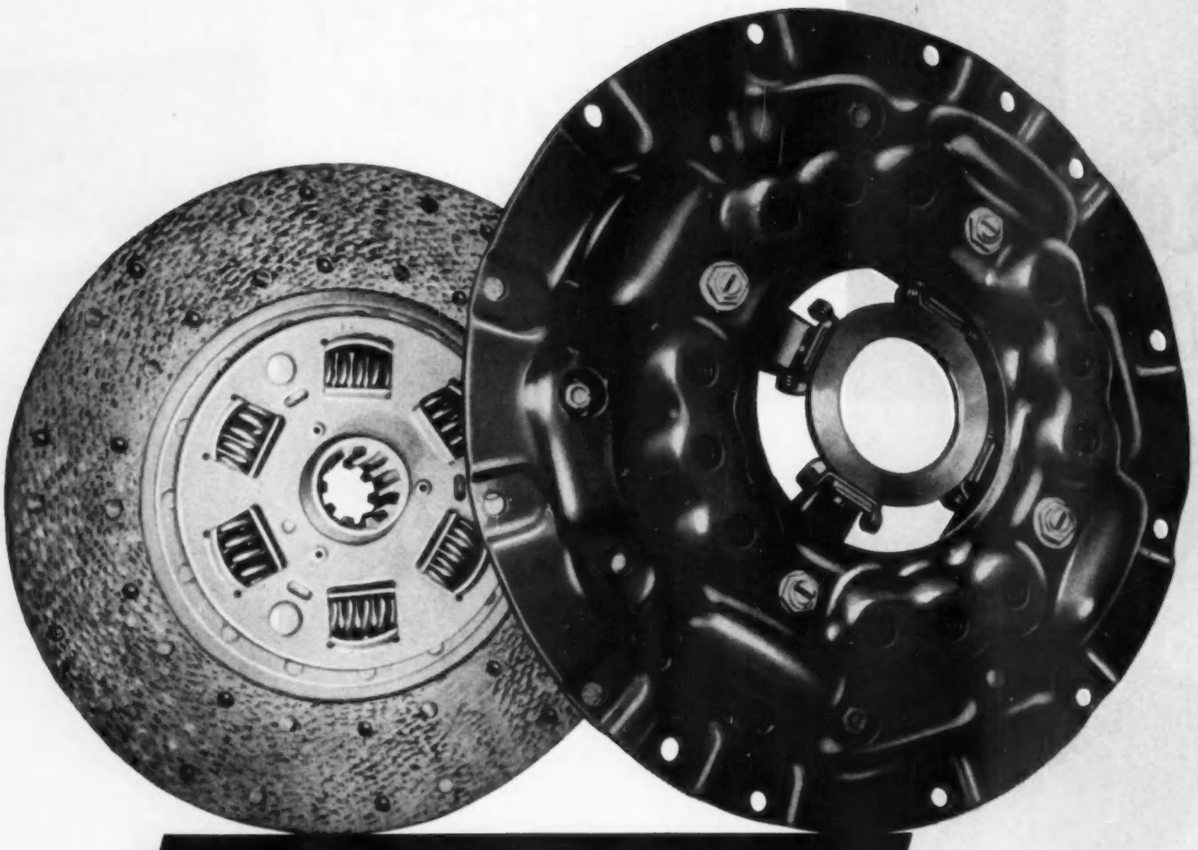

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large and small

Borg & Beck clutches are made in a wide range of sizes, from those for light cars to large twin-plate clutches for very heavy equipment.

They incorporate the experience gained in the design and manufacture of twelve million British made clutches and embody many distinctive features which ensure consistent and dependable performance.

The top illustration shows the 15-inch single dry-plate clutch, one of a range of 'strap-drive' clutches in which the pressure plate moves without metal-to-metal sliding contact. The smaller unit is a 6½-inch clutch.

Catalogue of Borg & Beck clutches and Rockford over-centre clutches and power take-offs on application.

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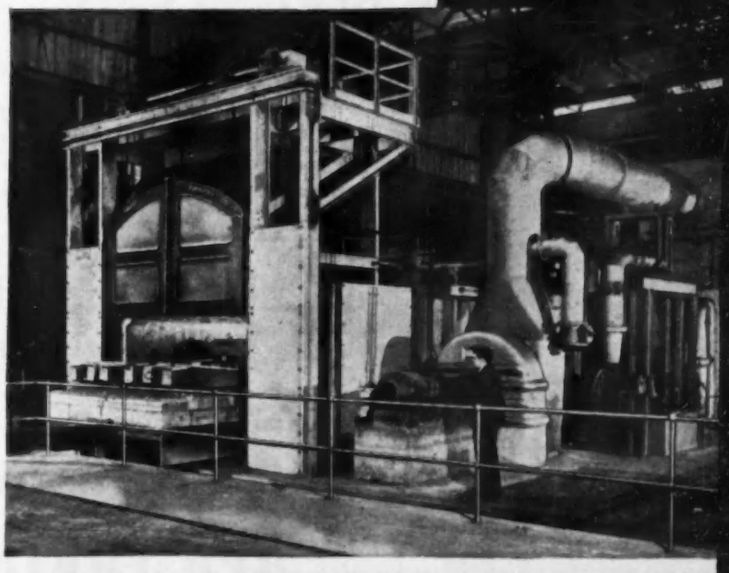
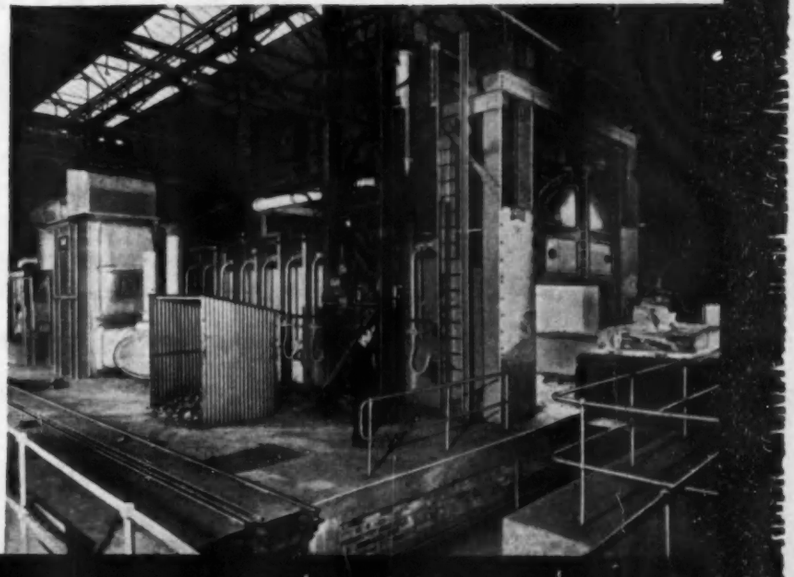


Illustrated is a Gas-fired Furnace supplied to Jessop-Saville Ltd., Brightside Works, Sheffield, for reheating alloy steel ingots prior to rolling.



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Soaking Pits of all types.

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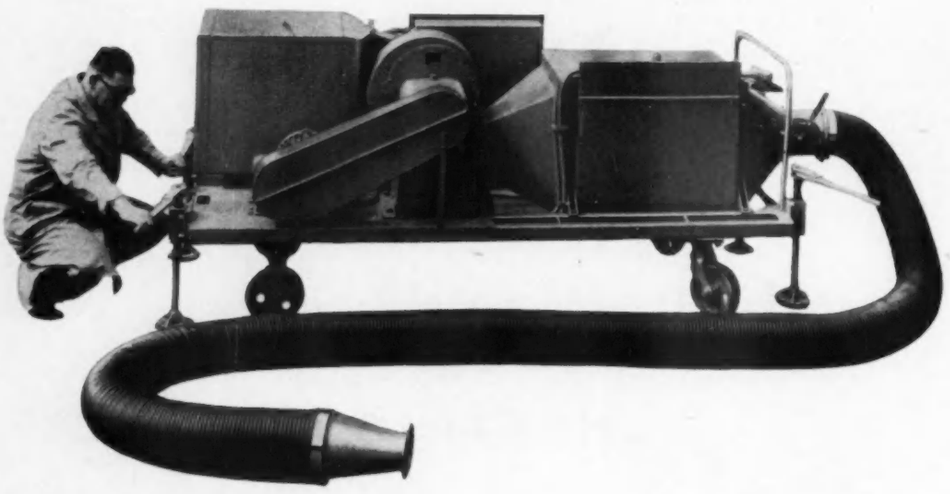

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This equipment was specially designed and built by **HEATREA LTD.** *for the purpose of drying aircraft components. The unit is built on a portable trolley, and comprises an electrically driven fan, filter, air heater, control panel and a flexible air delivery hose. The trolley is equipped with hand-jacks to ensure stability in operation.*

LOADING: 40kW.

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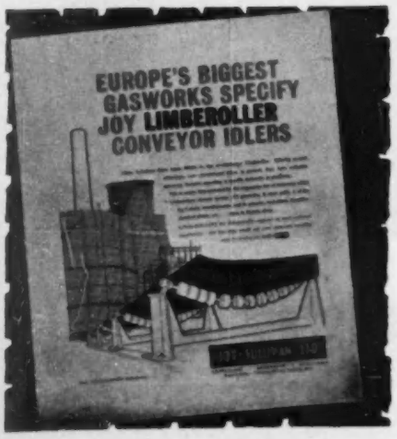
Europe's biggest gasworks, Britain's biggest cement manufacturers, fertilizer factories, foundries, mines, gravel pits and quarries . . . All over Europe, Joy Limberollers are taking the limelight as the *nearest technically perfect idler yet devised.* Only 2 self-lubricating bearings; flexible steel cable suspension; perfect catenary belt support; non-wearing, non-inflammable Neoprene roller, non-spilling, 'cushioned' ride.



These and many other advantages pinpoint British-made Joy Limberoller idlers as the biggest advance in materials handling in years.

★ AND YOUR APPLICATION ?

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Limberoller idlers are now available with modifications for rope conveyor systems. If you use rope conveyors the new LIMBEROPE publication should be at your elbow. Please ask for a copy.

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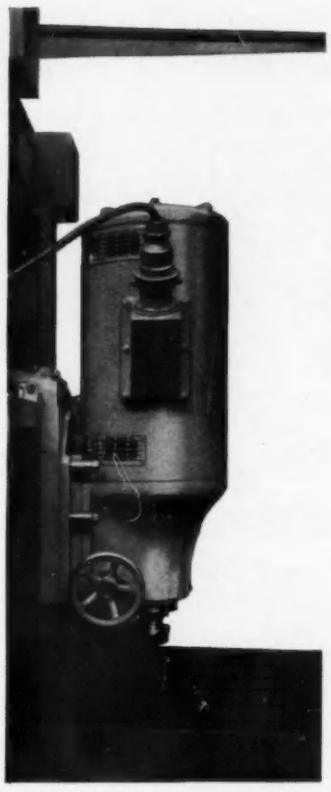

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MILLING HEAD

For Planing Machines

This new design of high speed milling head has been specially designed for use on planing machines and employs a fairly small milling cutter rotating at a very high speed so that a rapid table feed can be maintained (generally about 4 f.p.m. for roughing and 8 to 10 f.p.m. for finishing). In this way as much as 40 h.p. can be absorbed at the cutting tool.

The head consists of a special design of two-speed motor whose extended spindle is supported in large precision grade Timken bearings in a suitable housing. The cutter or adaptor is mounted directly on to the spindle, the B.S.I. taper of 3½" per foot being provided in the spindle nose. The draw bar at the other end of the spindle makes for the easy insertion and removal of the cutter. The head is equipped with means of securing it to the base slide of any toolbox and has an auxiliary slide enabling it to be adjusted to or from the job.

The motor is so arranged that it can be connected to the power supply by a simple plug and socket arrangement and it is not necessary to screw any connections into a terminal box, etc. A range of standard cutters with additional spare blades is provided as part of the equipment with each milling head.

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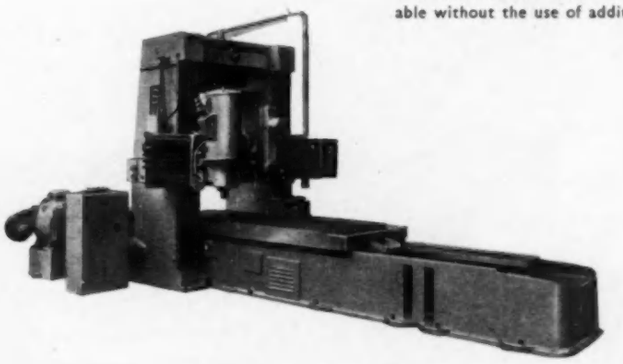

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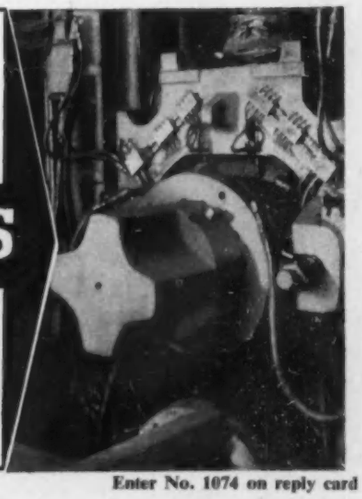

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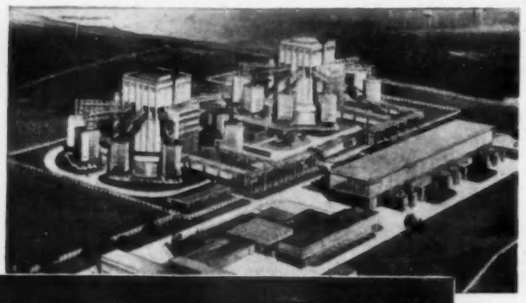

BERKELEY
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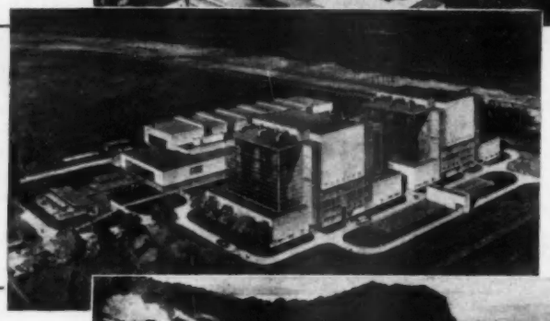

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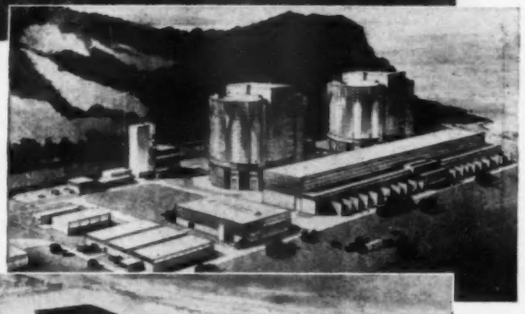

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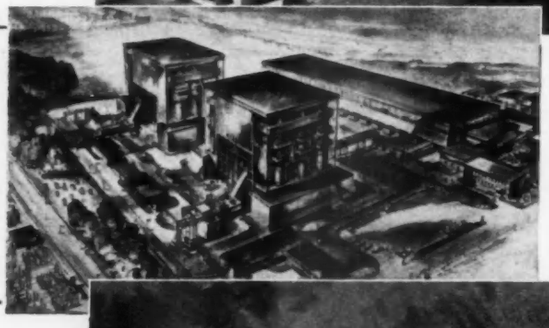

HINKLEY POINT
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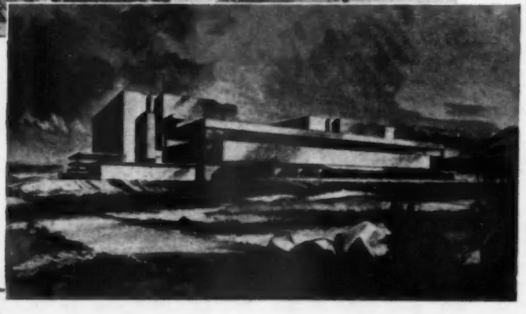
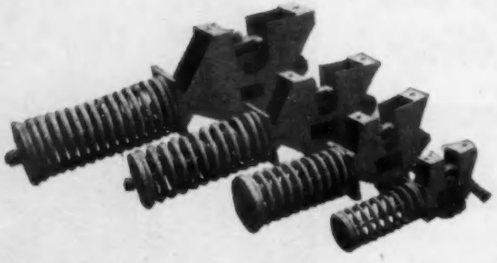


TRAWSFYNYDD (Atomic Power Constructions Ltd.)
(An impression by Sir Basil Spence, Consultant Architect to Nuclear Civil Constructors, showing how the design blends into the landscape of Snowdonia)



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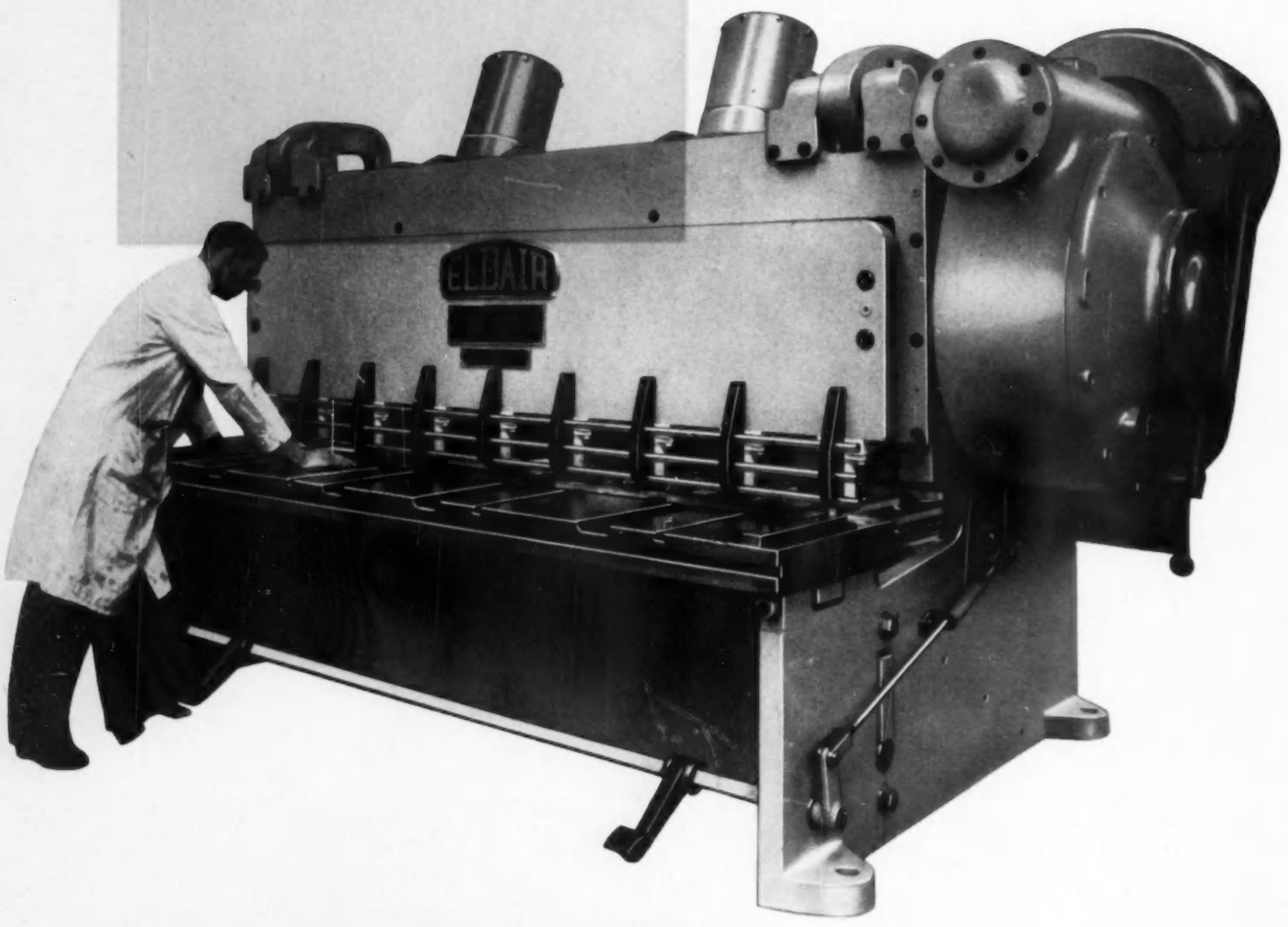

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Built in a range of standard sizes up to 12 ft. (longer on request) and up to 1 inch. capacity, Eldair Shears incorporate many special features to assist faster, accurate strip or plate shearing. Straight sided knives for increased strength and easier grinding; a sheer angle which virtually eliminates distortion of the cut material; instantaneous gripping and release by hydraulic hold-downs, individually adjustable to operate on varying thicknesses at the same time, are some of them.
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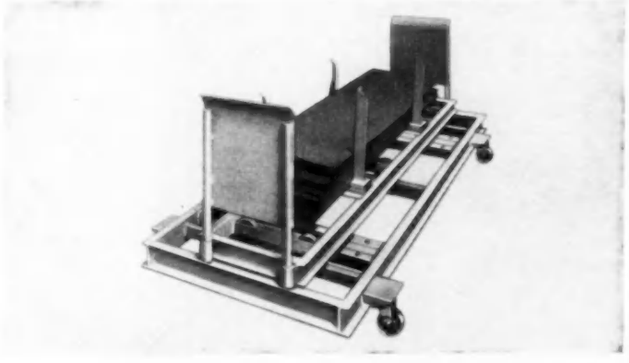
STRIPVEYOR

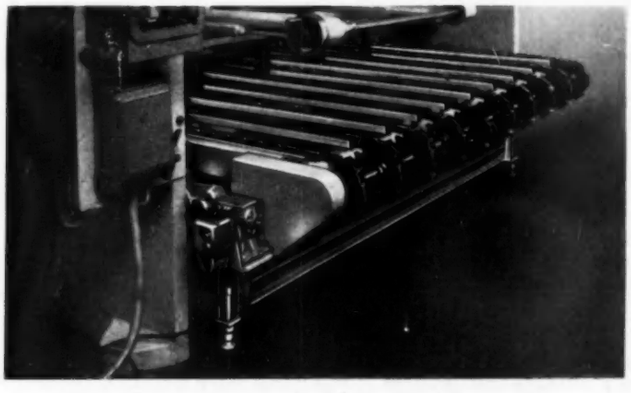
Automatically picks up and carries strips beyond shear bed. As each section is sheared it slides down the adjustable pick-up chute which butts against the bed of the shear, delivered to the table and then transferred to the STRIP STACKER.



WELDALL-FRIED

STRIP STACKER

Ensures greater speed and convenience in all strip handling. The STRIP STACKER receives cut material from the STRIPVEYOR stacks it neatly in dollies and as these are filled can be moved back from the STRIPVEYOR and replaced by others.

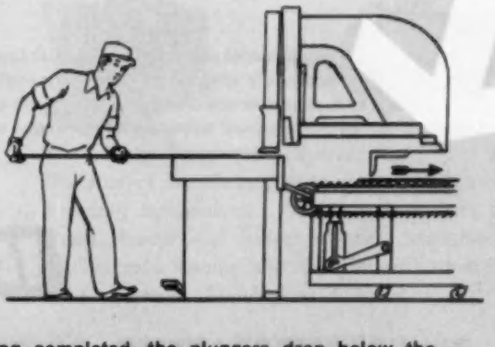


WELDALL-FRIED

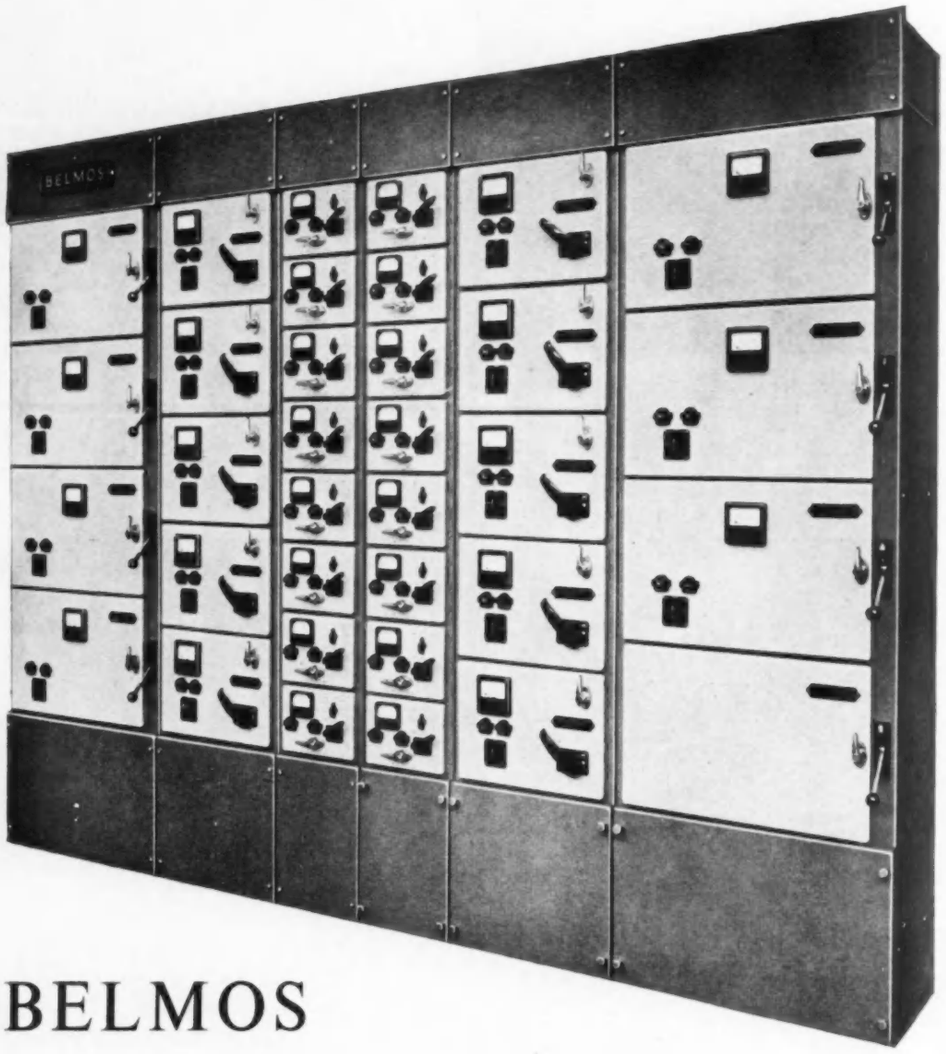
LIFTVEYOR

Clean-cut shearing to 5/1000 in. regardless of material is now possible with the aid of the LIFTVEYOR. Supports sheets as narrow as 8 in. and any back-gauge width. Capacity of standard model—M.S. sheet $\frac{1}{4}$ in. thickness. Heavy Duty model—M.S. plate to $\frac{3}{4}$ in. thickness. Extra Heavy Duty—$\frac{3}{4}$ in. Thick Mild Steel.

The LIFTVEYOR support is a pneumatically-operated series of plungers which rise to the table height of shear. Plungers are actuated by a treadle that is placed beneath the shear-bar and thus synchronized with the shear.



Shearing completed, the plungers drop below the level of back-gauge and the sheared material is carried away on the revolving belts. Return of the plungers to the support position is delayed to permit the sheared material to pass over.
Plunger assembly, mounted on carriage, may be moved in both directions horizontally to point of most effective support.



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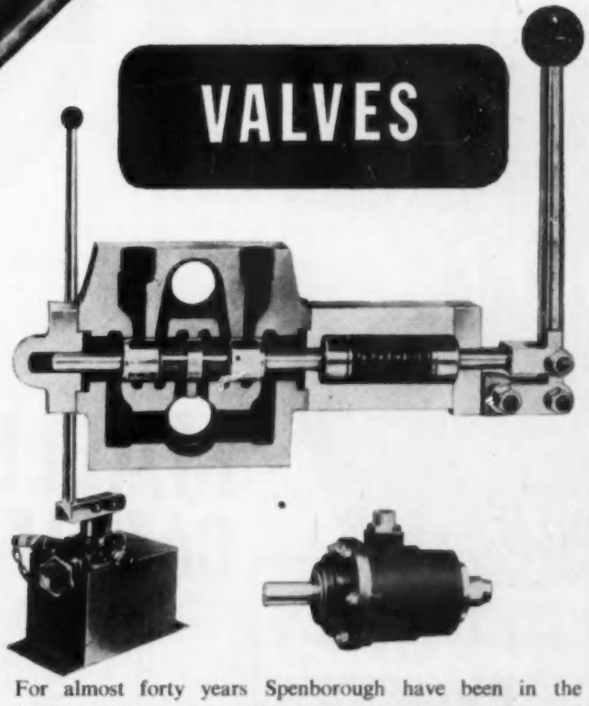

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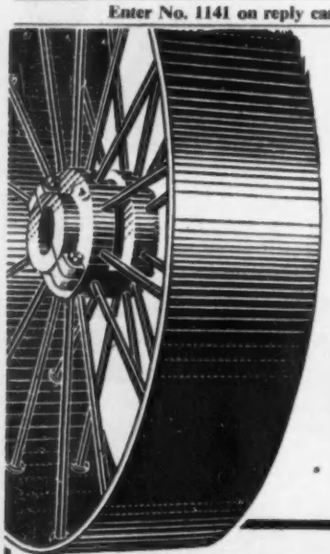

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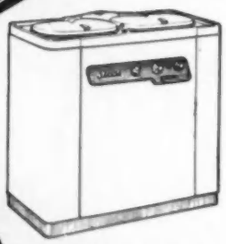

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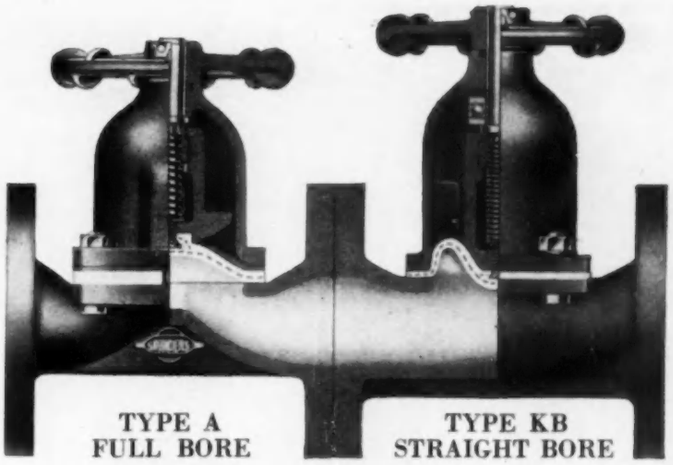

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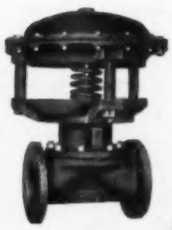

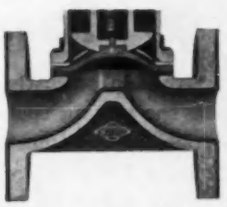

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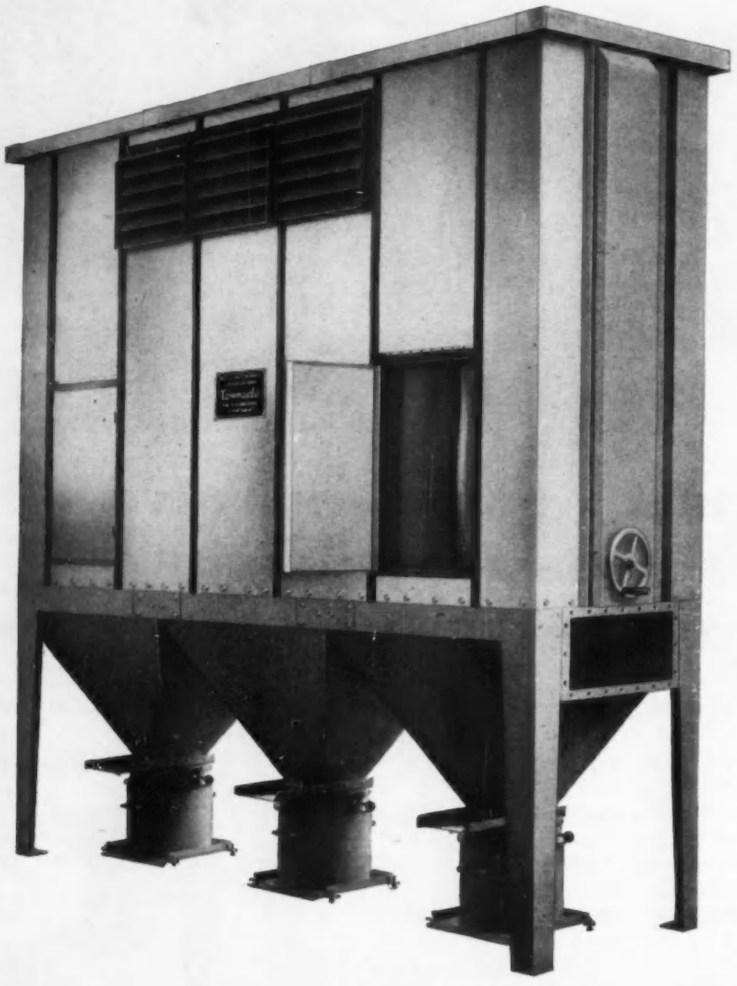

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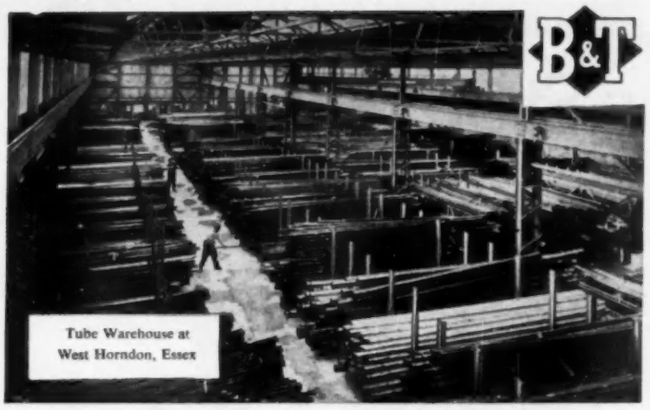

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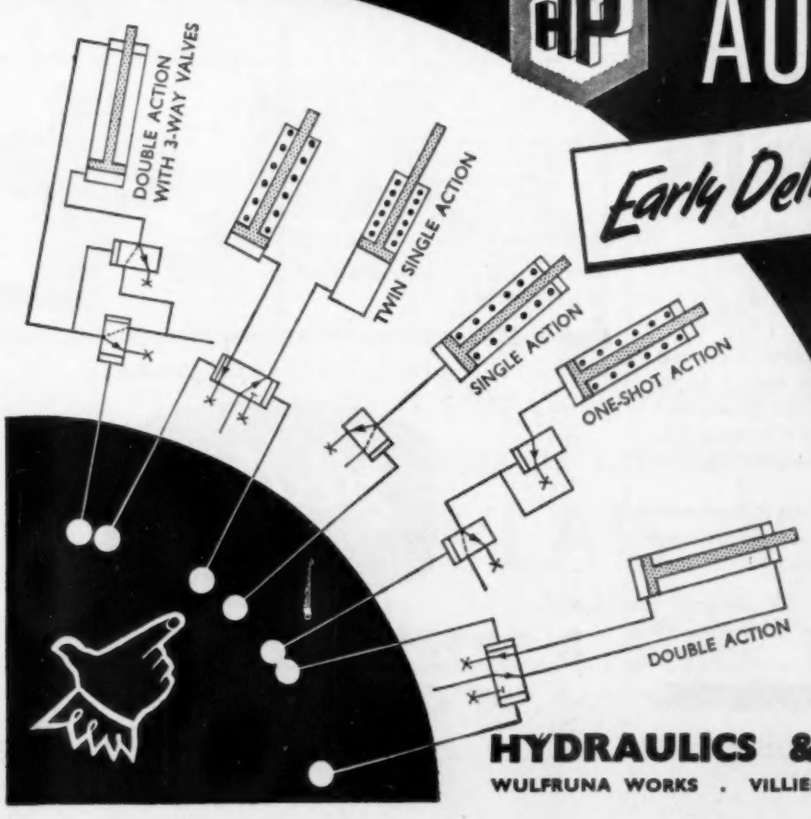

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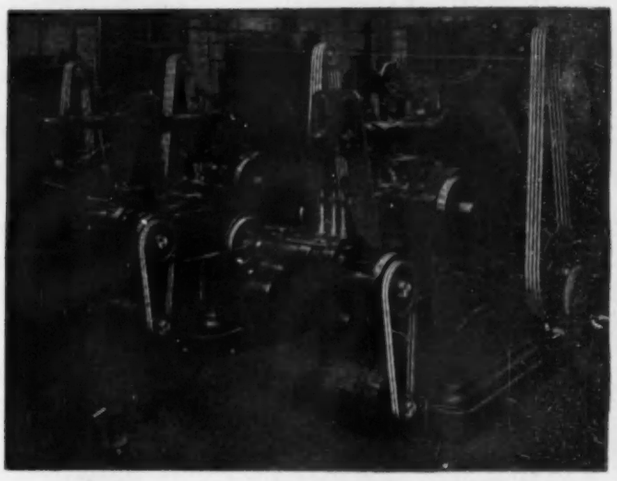

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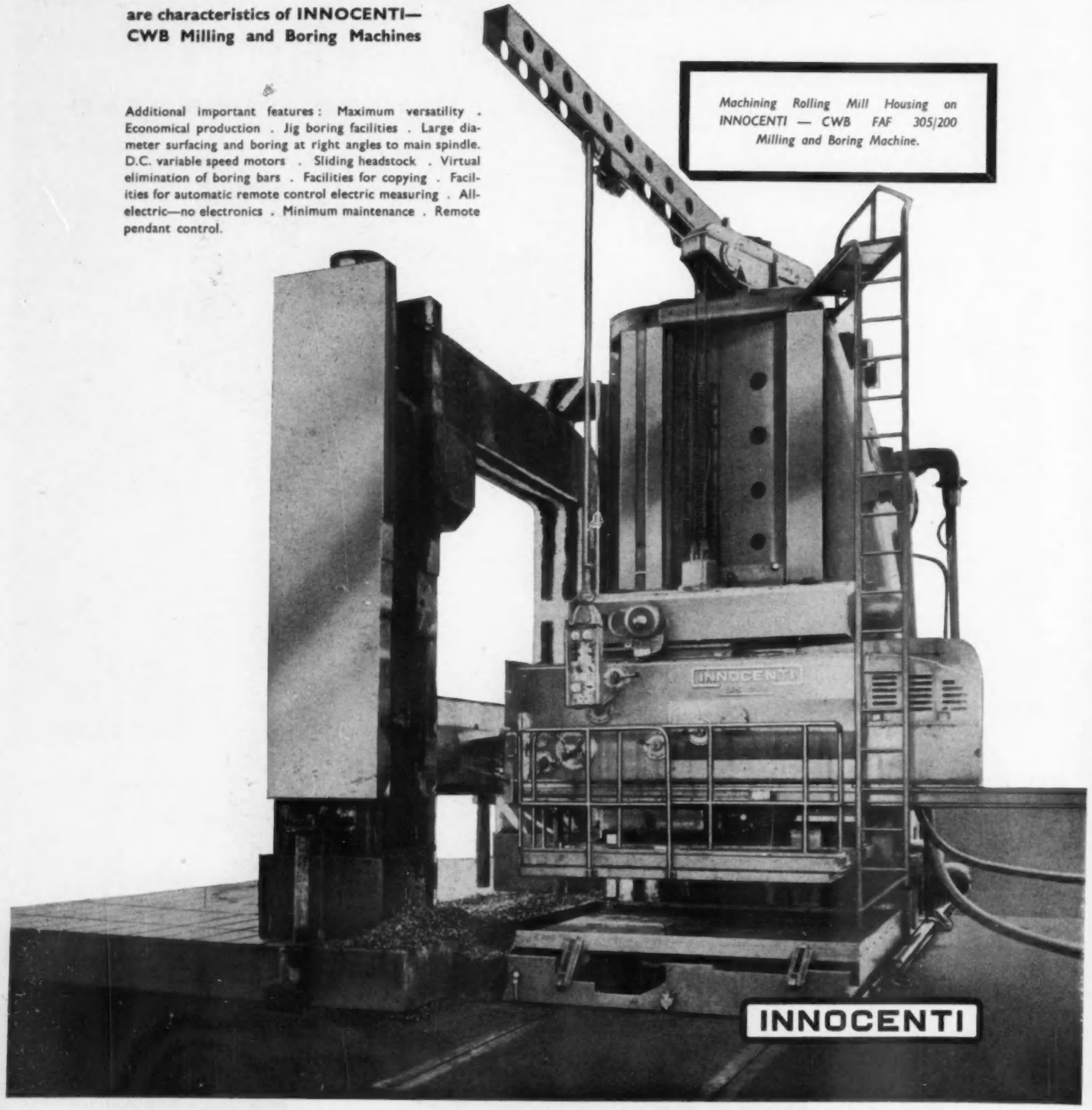

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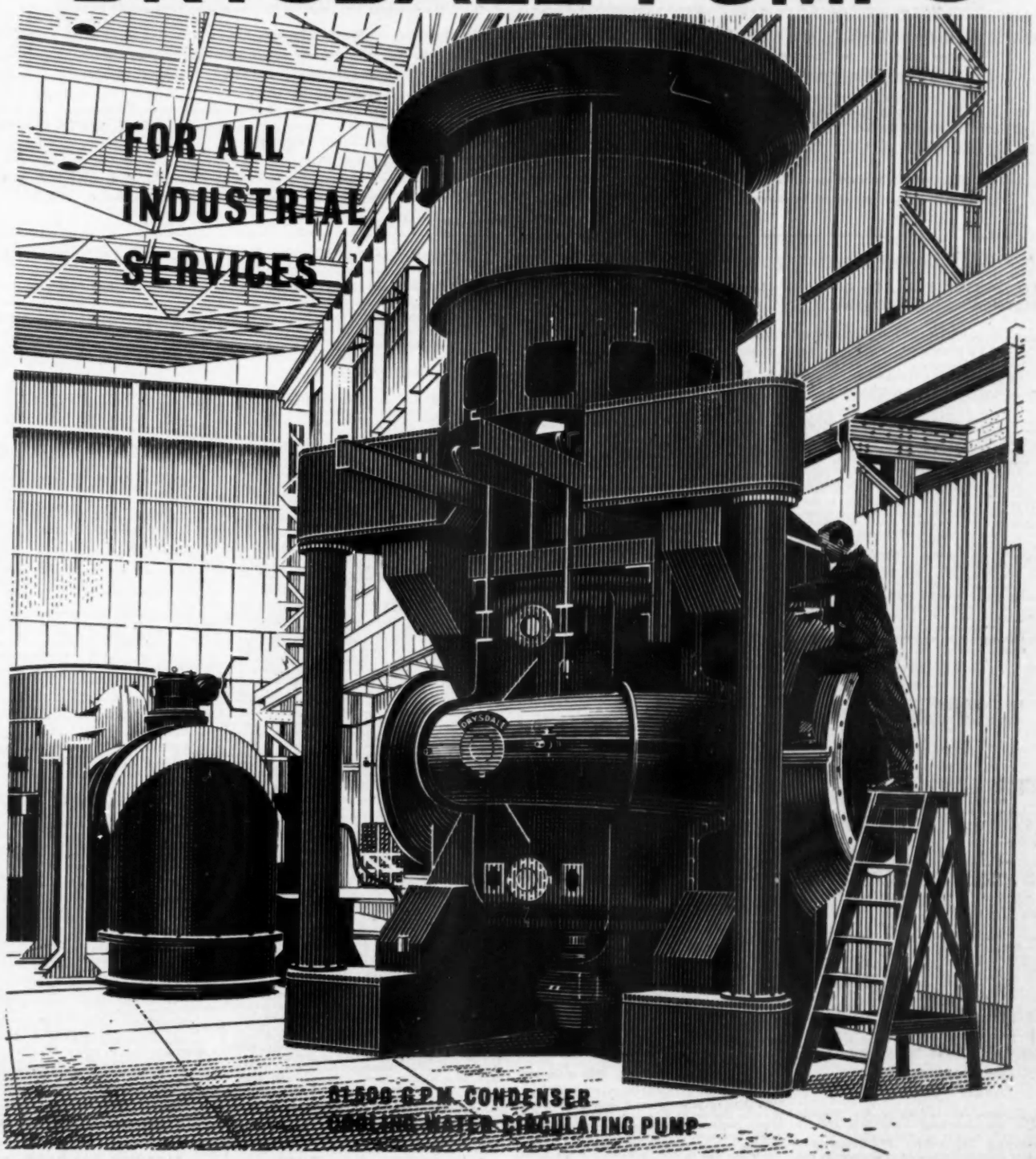

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Lineage Rate. 4/6 per line of approximately 6 words. Minimum 18/-. **Inch Rate.** 54/- per single column inch and pro rata. 12 lines to 1 inch.
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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.
Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.
Use of Box Number. 2/- which includes forwarding of replies.
Copy Dates. Tuesday for publication on Friday of the same week. If proofs are wanted, copy is required on Thursday for publication on Friday of the following week.
***Advertisements for publication should be addressed to:*—Classified Advertisement Dept., "THE ENGINEER," 28 Essex Street, Strand, London, W.C.2**
Urgent advertisements may be telephoned to CENtral 6565.

PUBLIC APPOINTMENTS

LANCHESTER COLLEGE OF TECHNOLOGY, COVENTRY

Principal : A. J. RICHMOND, B.Sc. (Eng.), Ph.D., M.I.Mech.E.

PRINCIPAL LECTURER IN PRODUCTION ENGINEERING

Applications are invited for the above post, duties to commence as soon as possible. The person to be appointed will rank as Deputy Head of Department.
The candidates should hold appropriate academic and professional qualifications, and have had substantial industrial experience in Production Engineering. Previous teaching or research experience would be an advantage.
The Department is now in new buildings in the centre of Coventry, and has a range of laboratories and workshops with completely new and modern equipment. The post offers considerable scope to an energetic person who is anxious to make a contribution to the Department of Production Engineering in a centre of industrial activity.
Salary (men) : £1750 by £50 to £1900 p.a. In certain circumstances, candidates may be paid a commencing salary above the minimum of the scale.
Application forms and further particulars may be obtained from the Registrar, Lanchester College of Technology, Priory Street, Coventry, to whom completed forms should be returned by 15th September, 1960.

W. L. CHINN,
E5823 Director of Education.

UNIVERSITY COLLEGE OF THE WEST INDIES

LECTURESHIPS

Applications are invited for LECTURESHIP in each of the following :
CIVIL ENGINEERING—candidates interested in Hydraulics preferred.
MECHANICAL ENGINEERING—candidates interested in Heat Engines, Theory of Machines or Design preferred.
The successful candidates will be expected to help with the planning of new Engineering laboratories and to organise temporary laboratories for use until the permanent laboratories become available. Duties to be assumed on or before June, 1961. Salary scale (under review) : £1150 by £50 to £1450 by £75 to £1900 p.a., entry point determined by qualifications and experience. Child allowance. F.S.S.U. Unfurnished accommodation at rental not in excess of 10 per cent. of basic salary. Passages for up to 5 persons on appointment, normal termination and study leave (once every 3 years). Detailed applications (6 copies) naming 3 referees by 30 September, 1960, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained. E5806

UNIVERSITY OF QUEENSLAND

LECTURERS

Applications are invited for the following positions. The salary range is £A1830 by £A70 to £A2330.
LECTURER IN CIVIL ENGINEERING : Applicants should be graduates in Engineering and have had experience in research in or teaching of Structural Engineering, Applied Hydraulics or Soil Mechanics.
LECTURER IN MINING ENGINEERING : Applicants should possess a degree in Mining Engineering (preferably with Honours) from a recognised University and must have had operating and/or research experience in some branch of Mining Engineering (preferably in Coal Mining and Coal Preparation).
LECTURER IN SURVEYING : Applicants should hold a degree in which Surveying is the major subject, and have special interests and qualifications in Photogrammetry.
The successful applicants will enjoy the privileges of superannuation, study leave, travel grants and other benefits available to the academic staff.
Further particulars may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1, or from the Registrar, University of Queensland, Brisbane, Australia.
Applications close on 15th October, 1960. E5811

PUBLIC APPOINTMENTS

H.M. DOCKYARD TECHNICAL COLLEGES

ASSISTANT LECTURERS

ASSISTANT LECTURERS (Grade "A" or "B"). Pensionable (non-contributory) posts for men : two in Electrical Engineering (Portsmouth and Rosyth) ; one in Mechanical Engineering (Rosyth) ; one in Mathematics and/or Physics (Rosyth). Ability to help with other subjects essential. Appointment as soon as possible, preferably by January, 1961. Qualifications : University degree or equivalent and ability to teach special subject to H.N.C. standard. Burnham scales for Technical Colleges (no deduction for pension). Write Civil Service Commission, Burlington Gardens, London, W.1, for application form quoting 5180/60. Closing date 23rd September, 1960. E5748

NORTH RIDING EDUCATION COMMITTEE

CLEVELAND TECHNICAL COLLEGE, REDCAR

APPOINTMENTS

Applications are invited for the following posts to take effect as soon as possible.
1. ASSISTANT (GRADE "B") FOR ELECTRICAL ENGINEERING.
2. ASSISTANT (GRADE "B") FOR WORKSHOP ENGINEERING.

Forms and particulars available from me on receipt of stamped addressed envelope. Completed forms to be returned by 19th September, 1960.
F. BARRACLOUGH, County Hall, Northallerton. E8530

SURREY EDUCATION COMMITTEE

REDHILL TECHNICAL COLLEGE, REDSTONE HILL, REDHILL

APPOINTMENTS

Required as soon as possible a GRADE "A" ASSISTANT for ENGINEERING SUBJECTS, especially for work with day-release students.
Further particulars and application form from the Principal, Redhill County Secondary Technical School, Redstone Hill, Redhill.
Required as soon as possible, a TEACHER of ENGINEERING METALWORK and ENGINEERING DRAWING.
Further particulars and application form from the Principal. E5838

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

ENFIELD TECHNICAL COLLEGE, QUEENSWAY, ENFIELD, MIDDLESEX

LECTURERS

Required for 1st September, 1960 or as early thereafter as possible :
LECTURERS IN ELECTRICAL ENGINEERING (Two vacancies) to teach mainly light current electrical engineering subjects to the standard of the Higher National Diploma and Part III Examination of The Institution of Electrical Engineers. For one of these posts candidates will be required to teach Electronics and Radio Communication and for the other the ability to teach Electrical Measurements would be an advantage.
LECTURER IN MECHANICAL ENGINEERING to teach mechanical engineering subjects to Higher National Diploma standard. Preference given to a candidate able to offer Theory of Machines.
LECTURER IN CIVIL ENGINEERING to teach civil engineering subjects up to the Part II A.M.I.C.E. standard. Preference given to a candidate able to offer Building Construction.
Candidates should be University Graduates in Engineering, be Graduate or Corporate Members of the appropriate Institution and have had teaching and/or industrial experience.
Salary within the range : £1408 to £1601 per annum.
Application forms (foolscap s.a.e.) from the Principal, to whom completed forms should be returned within 14 days of the appearance of this advertisement.

C. E. GURR, M.Sc., Ph.D.,
Secretary to the
E5832 Education Committee.

PUBLIC APPOINTMENTS

MINISTRY OF AVIATION

NATIONAL GAS TURBINE ESTABLISHMENT, PYESTOCK, FARNBOROUGH, HANTS.

PLANT MANAGERS

Ministry of Aviation, National Gas Turbine Establishment, Pyestock, Farnborough, Hants., requires PLANT MANAGERS with H.N.C. and recognised apprenticeship for two posts :
Post A (Ref. D.559/OA). Control, operation and maintenance of an extensive electrical installation of 300MW. Qualifications : Intimate knowledge of : Transformers up to 60MW ; outdoor and indoor switchgear up to 132KV and rupturing capacity of 750MVA ; motors and generators up to 37,000 h.p. per unit and protection systems (generating experience on major power station most desirable) ; distribution at 11KV including ring main substations and fault locating principles and equipment. Successful candidate will require to have or obtain certificate of approval from Central Electricity Generating Board for the performance of certain switching operation of their equipment on site and must be fully conversant with relevant safety rules and procedures.
Post B (Ref. C.676/OA). Control, operation and maintenance of extensive mechanical installations aggregating 400,000 h.p. Qualifications : Sound knowledge of : Modern steam-raising plant and ancillaries up to 650,000 lb/hr. ; separate oil-fired superheater with external steam mains and flow of 250,000 lb/hr. ; steam turbines in the 10,000 h.p. class and experience in taking them on and off load quickly ; very large cooling water installations and base exchange softening plants, and of the regulations governing the handling of caustic soda and sulphuric acid ; tank farm installations for kerosene and fuel oil up to one million gallons and relevant safety regulations ; very large axial and centrifugal blowers including anti-surge protection devices and blow-off valves and air valves up to 6ft. diameter. Salary : £1295 to £1491. Forms from Ministry of Labour, Technical and Scientific Register (k), 26 King Street, London, S.W.1, quoting appropriate reference. E5825

MINISTRY OF AVIATION

NATIONAL GAS TURBINE ESTABLISHMENT, PYESTOCK, HANTS

ENGINEERS

Ministry of Aviation require ENGINEERS at National Gas Turbine Establishment, Pyestock, Hants., to assist in plant and services planning and relief plant operation for engine test cells and facilities for large gas turbines. Qualifications : Applicants should have served recognised engineering apprenticeship and be corporate Members of Institution of Civil, Mechanical or Electrical Engineers or equivalent. Experience in design and layout or operation of services installations of water, heating mains, boilers, &c. Experience in design of pressure pipework advantageous and applicants should, after reasonable training, be willing and competent to take part in relief plant operation. Salary : £780 (age 25) to £1220 p.a. Commencing salary £1065 p.a. at age 34 or over. First class experience for men interested in this field of work with excellent career prospects and opportunities for establishment. Applications : Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C667/OA. E5810

SOUTHAMPTON CORPORATION WATERWORKS

SENIOR CIVIL ENGINEERING ASSISTANT

Applications are invited for the above appointment which is on the permanent establishment, salary in accordance with A.P.T. Grade IV (£1065 to £1220).
Applicants must be Associate Members of the Institution of Civil Engineers, and experience in Waterworks practice is essential.
Housing Accommodation available in approved cases and approved removal expenses reimbursed up to a maximum of £50.
Conditions of appointment and forms of application from C. A. Bradley, B.Sc., M.I.C.E., Waterworks Engineer and Manager, Civic Centre, Southampton.
Applications to be returned by Tuesday, September 20th, 1960. E5824

PUBLIC APPOINTMENTS

ADMIRALTY

ROYAL NAVAL SCIENTIFIC SERVICE

SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS

Royal Naval Scientific Service require SENIOR SCIENTIFIC OFFICERS AND SCIENTIFIC OFFICERS in establishments in following locations : London Area, Haslemere, Baldock, Poole, Cheltenham, Portland, Portsmouth.
Applications invited from graduates and post-graduate research workers with the following interests :
PHYSICS (classical, mathematical and electronic) ; ELECTRICAL ENGINEERING (electronic, telecommunications and radio) ; MATHEMATICS (pure and applied) ; HYDRODYNAMICS, MECHANICAL ENGINEERING (including servo-mechanisms, gyroscopes and welding development) ; CHEMISTRY (ceramics with solid state properties).
Candidates must normally be natural born British subjects of natural born British parents, with First or Second Class Honours Degrees or equivalent qualifications. S.S.Os must have had three years' post-graduate experience and be not less than 26 years of age. Salaries (men) S.S.O. £1330 to £1640; S.O. £730 to £1205 (London), somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between ages of 21 and 32 to compete for established posts. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Order No. A.359/OA.
E5754

AIR MINISTRY

ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS

Air Ministry require ASSISTANT MECHANICAL AND ELECTRICAL ENGINEERS for design, construction and maintenance of installations on airfields, radar stations, missile bases, workshops and maintenance units for R.A.F. at home and overseas as well as certain Civil Airports. Salary—£805 at 25 to £1095 at 34 or over, thereafter rising to maximum £1260 with increase for London and slight decrease for country districts. Appointments non-pensionable but long term. Promotion prospects. 5 day week with 4 weeks 2 days leave a year initially. Special allowance in addition to salary during overseas service. Qualifications and experience :
(i) (a) University degree or equivalent diploma in electrical and/or mechanical engineering with at least 2 years apprenticeship ; or
(b) Graduate or corporate member of I.E.E. with at least 3 years apprenticeship ; or
(c) Graduate or corporate member of I.Mech.E. appreciable electrical engineering experience with at least 3 years apprenticeship ; and
(ii) Have been employed for minimum of 2 years with well established engineering concern and gained wide experience in both electrical and mechanical engineering practice.

Applicants must be natural born British subjects between ages of 25 and 45. Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting D.158/OA.
E5671

RHODESIA RAILWAYS

VACANCIES FOR SIGNAL AND COMMUNICATIONS TECHNICIANS

Applications are invited to fill vacancies in Rhodesia for SIGNAL AND COMMUNICATIONS TECHNICIANS who are qualified in performing both signalling and telecommunications work, also applicants qualified to perform either mechanical or electrical work.
Single men between 25 and 35 years of age preferred but married men within this age limit will be accepted provided they are prepared to travel to Rhodesia alone in the first instance.
Salary scale : 62s. 6d. to 68s. per day.
Free passage, pension, good service conditions, including annual leave with pay, sick pay, and good prospects of advancement.
Applications in writing should be addressed to :
The London Agent,
Rhodesia Railways,
241, Salisbury House,
London Wall, London, E.C.2. E5798

PUBLIC APPOINTMENTS

GOVERNMENT OF THE FEDERATION OF RHODESIA AND NYASALAND

DEPARTMENT OF CONSERVATION AND EXTENSION (NORTHERN RHODESIA) MINISTRY OF AGRICULTURE

MECHANICAL ENGINEER

Applications are invited from persons holding a recognised degree in Mechanical Engineering or corporate members of the Institute of Mechanical Engineers, with experience in workshops and field organisation of plant and equipment. Experience in works costing and stores control will be an added recommendation.

Duties will include the organisation and control of the Department's fleet of heavy crawler tractors, ancillary equipment and vehicles, workshops and stores, and advising on mechanical matters.

Salary scale : £1785 to £1863 15s. to £1942 10s. per annum.

Application forms and further details from the Secretary (R), Rhodesia House, 429 Strand, London, W.C.2. Closing date 30th September. E5790

MINISTRY OF AVIATION

NATIONAL GAS TURBINE ESTABLISHMENT, PYESTOCK, HANTS

ENGINEER

Ministry of Aviation requires ENGINEER at National Gas Turbine Establishment, Pyestock, Hants, to assist in planning, organisation and supervision of operation, maintenance and overhaul of high-speed rotating machinery and/or heavy mechanical engineering plant including steam boilers, superheaters, turbo-blowers, valves, &c. Qualifications : Recognised engineering apprenticeship and be corporate Members of Institution of Civil, Electrical or Mechanical Engineers or equivalent. Experience in mechanical engineering plant operation and maintenance and preferably knowledge of engine test facilities for large gas turbines. Salary : £780 (age 25) to £1220 p.a. Commencing salary £1065 p.a. at age 34 or over. First class experience for men interested in this field of work with excellent career prospects and opportunities for establishment. Applications : Forms from Ministry of Labour, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C668/OA. E5809

NORTH THAMES GAS BOARD

TAR AND AMMONIA PRODUCTS WORKS

DRAUGHTSMAN

DRAUGHTSMAN, aged 21 or over, with O.N.C., required by North Thames Gas Board at the Tar and Ammonia Products Works, Beckton, East Ham, E.6.

The post offers the possibility of obtaining experience in the expanding field of chemical engineering for an applicant who has had a sound mechanical training.

Starting salary will be according to qualifications and experience, and the successful candidate will be required to join a contributory Staff Pension Scheme. Five-day week.

Applications, giving age and full particulars, should be sent to the Staff Controller, North Thames Gas Board, 30, Kensington Church Street, W.8, quoting reference TE/839. E5835

METROPOLITAN WATER BOARD

SENIOR ASSISTANT ENGINEER (MECHANICAL)

Applications are invited for the above-mentioned appointment on the permanent pensionable staff.

Salary scale : £1365 to £1500 per annum. Commencing salary according to age, qualifications and experience. Maximum age 45 years.

Applicants must be corporate members of the Institution of Mechanical Engineers. Good recent experience with leading pump manufacturers an advantage.

Housing accommodation may be available.

Further particulars and form of application from the undersigned, quoting reference (T.E.).

S. D. ASKEW,
Clerk of the Board.

New River Head,
Rosebery Avenue,
London, E.C.1. E5818

NORTH THAMES GAS BOARD

MONCK STREET, WESTMINSTER, S.W.1

SENIOR DRAUGHTSMEN

Applications are invited for the above appointments in North Thames Gas Board at Monck Street, Westminster, S.W.1, for the design and detailing of any of the following :

(a) Reinforced concrete structures and foundations
(b) Coal and Coke Handling and Screening Plant.
(c) Steel structures.
(d) Mechanical Plant and pipework associated with gasworks.

The appointments will be permanent and the successful candidates will be required to join the Board's contributory pension scheme.

Salaries will be in accordance with qualifications and experience.

Applications, stating age, qualifications and experience, should be sent to the Staff Controller, North Thames Gas Board, 30, Kensington Church Street, W.8, quoting reference TE/887. E5837

PUBLIC APPOINTMENTS

SOUTH WESTERN REGIONAL HOSPITAL BOARD

BRISTOL

APPOINTMENTS

Applications are invited for the following posts in the Board's Engineering Department at Bristol :

(a) MAIN GRADE ENGINEER (MECHANICAL). Salary scale : £910 by £35 (1) by £40 (2) by £45 (5) by £50 (7) to £1600.

(b) ENGINEERING DRAUGHTSMAN I (ELECTRICAL). Salary scale : £1030 by £35 (2) by £50 (3) to £1250.

Candidates for (a) must hold the qualification of A.M.I.Mech.E. or A.M.I.H.V.E., and be able to design mechanical engineering services for hospital buildings.

Candidates for (b) should possess Higher National Certificate (Electrical Engineering), or equivalent qualification, with suitable practical training and site or workshop experience, and be able to design electrical installations for hospitals.

Appointments are subject to N.H.S. Superannuation Regulations and Whitley Council salary scales.

Applications, stating qualifications, experience, present post and salary, with names of two referees, to be forwarded by Monday, 1st October, 1960, to M. O. Carter, Secretary, S.W. Regional Hospital Board, 27, Tyndalls Park Road, Bristol, 8. E5785

BRITISH TRANSPORT COMMISSION

BRITISH RAILWAYS SCHOOL OF TRANSPORT, DERBY

DIESEL TRACTION INSTRUCTORS (TWO POSTS)

British Transport Commission invite applications for the following posts at the British Railways School of Transport, Derby :

DIESEL TRACTION INSTRUCTORS (two posts). Salary range : £1260 to £1490 p.a.

Instruct Technical and Supervisory staff in the principles of diesel traction, methods and problems of transmission and control, and the operation and maintenance of diesel locomotives and Multi-Unit Stock. One post is for an instructor to deal mainly with electrical subjects, the other with mechanical. Sound theoretical knowledge and practical experience of medium and high-speed diesel engines used in rail traction essential. Professional engineering qualifications required. Experience in teaching desirable. Posts are non-residential.

Superannuation scheme : certain travel facilities : medical examination. Write, stating age, qualifications and experience, to Director of Establishment, British Transport Commission, 222 Marylebone Road, London, N.W.1, within 7 days. E5816

MANCHESTER CORPORATION WATERWORKS UNDERTAKING

DEPUTY ENGINEER AND MANAGER

Applications are invited for the appointment of DEPUTY ENGINEER AND MANAGER of the Manchester Corporation Waterworks Undertaking. Applicants should be Civil Engineers with administrative experience, preferably having a wide experience of the design and construction of large civil engineering works for water supply.

Commencing salary £2753 per annum, rising by annual increments of £90 to £3023 per annum.

Details of appointment and application forms (returnable by 26th September, 1960) from the Secretary, Waterworks Department, Town Hall, Manchester 2. E5758

WAR OFFICE

TECHNICIAN

War Office requires TECHNICIAN in London to assist in planning and progressing production of fighting vehicle equipments and repair schemes. Range covers mechanical, electrical and electronic equipments. Qualifications : Minimum O.N.C., H.N.C. preferred with recognised engineering apprenticeship or equivalent training in appropriate trade. Experience preferably in both mechanical and electrical fields. Production experience and ability to assess manufacturing capacity advantage. Salary : £1065 to £1300 p.a. Forms from Ministry of Labour, Technical and Scientific Register (K), Almack House, 26 King Street, London, S.W.1, quoting C 673/OA. E5827

MINISTRY OF TRANSPORT

CIVIL ENGINEERS

CIVIL ENGINEERS. Pensionable posts for men and women at least 25 and under 35 on 1st January, 1960 (extension for regular Forces service, Overseas Civil Service, established civil service, and temporary Government service as Civil Engineer). Candidates must have achieved Corporate Membership of Institution of Civil Engineers or passed examinations necessary for attaining such membership. Experience in road and bridge construction essential ; knowledge of Highways Authorities' procedure desirable. Salary (men, London) £830 to £1125 according to age, rising to £1300. Promotion prospects. Write Civil Service Commission, 17 North Audley Street, London, W.1., for application form, quoting S/64. E5826

PUBLIC APPOINTMENTS

COLLEGE OF ADVANCED TECHNOLOGY, BIRMINGHAM

Owing to the continued expansion of the College following its designation as a College of Advanced Technology, applications are invited for staff appointments in the following departments :

ELECTRICAL ENGINEERING
MECHANICAL ENGINEERING
PRODUCTION ENGINEERING
BUILDING AND CIVIL ENGINEERING
METALLURGY
CHEMISTRY
PHYSICS
MATHEMATICS
INDUSTRIAL ADMINISTRATION

In each department there are vacancies at the principal lecturer, senior lecturer and lecturer level, the salary scales for these grades being :

PRINCIPAL LECTURER	£1750 - £1900
SENIOR LECTURER	£1550 - £1750
LECTURER	£1370 - £1550

Candidates should hold an Honours Degree and be members of the appropriate professional institution, or hold equivalent qualifications, with experience according to grade and subject of teaching, research, industrial or professional practice.

All courses are of first degree or post-graduate standing ; there are facilities for research work and consultancy which are encouraged. Most of the full-time courses are of the sandwich type leading to the Diploma in Technology (Engineering or Applied Science) and demand close contact and integration between academic work of high standard and industrial training and experience.

Application forms and detailed particulars can be obtained from

The Bursar,
COLLEGE OF ADVANCED TECHNOLOGY (Ref. : 760/J)
COSTA GREEN,
BIRMINGHAM, 4.

K. R. PILLING, Clerk to the Governors.

E5780

TENDERS

INDIA STORE DEPARTMENT

20030/1/60/HSK/HAL (2)

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

20030/1/60/HSK/HAL (2)

	Nos.
(a) CAPSTAN LATHE with Double Slide, Capstan rest ; height of Centres 7¼in., swing over bed covers 14¼in.	2
(b) SENIOR CAPSTAN LATHE with preoptive Headstock. Max. swing under overhead support bar, 15¼in.; max. swing over cross-slide 8in.; working stroke of capstan 10¼in.	2
(c) PREOPTIVE COMBINATION TURRET LATHE ; swing over cross-slide 8in., swing not less than 10in. from cross-slide 16in.; max. distance, end of spindle to face of Turret 44in.	1
(d) TOOL ROOM PRECISION LATHE ; length between centres 1000mm.; swing over bed 450mm.; swing over carriage 225mm.	1

The Tender forms with schedules and specifications which are returnable on Monday, 3rd October, 1960, may be obtained from the above office (C.D.N. Branch) on payment of a fee of ten shillings (not refundable) for each Tender.

The applications for Tenders should clearly state the above reference number. E5779

SANDY GULLY PROJECT

JAMAICA

SELECTED TENDER

The Ministry of Development of the Government of Jamaica will shortly be calling for TENDERS on the above scheme. All persons interested should, in the first instance, send their names and addresses to the Permanent Secretary, Ministry of Development, 24 East Race Course, P.O. Box 512, Kingston, Jamaica, to reach him not later than the 17th September, 1960.

A deposit of One Hundred Pounds (£100) will be required for each Tender Document and will only be refunded on receipt of a bona fide Tender.

The Contractor is to arrange finance on a deferred payment basis over a period of seven (7) years.

The scheme includes Bridges, Earth works (in dry and wet areas), and Concrete Channel construction (approximately 6 miles) and will probably exceed One Million Pounds.

Will Contractors please note that only firms with experience in the above fields can be considered. E5792

TENDERS

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

PATCHAM PUMPING STATION

REMOTE AUTOMATIC CONTROL EQUIPMENT

FIXED PRICED TENDERS INVITED for the MANUFACTURE, DELIVERY, ERECTION, TESTING and SETTING IN OPERATION equipment for REMOTE and LOCAL AUTOMATIC CONTROL of Electrically Driven Submersible Well and Surface Booster Pumps.

Specification and Particulars from Chief Engineer, Water Department, 12 Bond Street, Brighton, on payment of Two guineas deposit to be refunded on receipt of a bona-fide Tender and return of all documents.

Tenders in plain sealed envelopes, endorsed REMOTE CONTROL, PATCHAM PUMPING STATION to be delivered to me by noon on 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton. E5735

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

BEVENDEAN RESERVOIR

TENDERS invited from Experienced Contractors for the CONSTRUCTION of a 1¼ million gallon REINFORCED CONCRETE RESERVOIR and ANCILLARY WORKS at Bevendean, Brighton.

Specification, Bill of Quantities and Contract Documents obtainable from Chief Engineer, 12 Bond Street, Brighton. Deposit of £5 5s. will be refunded on receipt of a bona fide Tender and return of documents supplied.

Tenders enclosed in plain sealed envelope not bearing any name or mark indicating the sender and endorsed "TENDER for BEVENDEAN RESERVOIR" to be delivered to me before noon on Friday, 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton. E5736

Classified Advts. continued on page 128

TENDERS

COUNTY BOROUGH OF BRIGHTON

WATER DEPARTMENT

PATCHAM PUMPING STATION CONTRACT NO. 4 STERILISATION PLANT

TENDERS invited for the MANUFACTURE, DELIVERY, ERECTION and SETTING TO WORK of STERILISATION EQUIPMENT at the above Pumping Station.

Copies of General Conditions of Contract, Drawings, Specification and Form of Tender obtainable from the Chief Engineer, 12, Bond Street, Brighton, 1. Deposit of £2 2s. will be refunded on receipt of a bona fide Tender and return of documents supplied.

Tenders enclosed in plain sealed envelopes not bearing any name or mark indicating the sender and endorsed "PATCHAM—CONTRACT No. 4—STERILISATION PLANT" must be delivered to me before noon on Friday, 30th September, 1960.

The Corporation do not bind themselves to accept the lowest or any Tender.

W. O. DODD,
Town Clerk.

Town Hall,
Brighton.

E5737

INDIA STORE DEPARTMENT

TENDER REF. NO. 16065/60/BMB/HAL

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

TENDER REF. No. 16065/60/BMB/HAL
ONE UNIVERSAL THREAD GRINDER ; distance between centres 20in. ; table traverse 21½in. ; maximum diameter to be ground 10in. maximum length of thread to be ground in one setting 19in.

The Tender forms with Schedule and Specifications which are returnable on 29th September, 1960, may be obtained from the above Office (Co-Ordination Branch) on payment of a fee of 10s. (not refundable) for each Tender.

Please quote the above reference number. E5814

INDIA STORE DEPARTMENT

TENDER REF. NO. 16068/60/BMB/HAL

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

TENDER REF. No. 16068/60/BMB/HAL
RODS, BARS, WIRES in various sizes in SILVER STEEL, H.S.S. ; SPRING STEEL ; C.M. STEEL ; NICKEL STEEL.

The Tender forms with Schedule and Specifications which are returnable on 29th September, 1960, may be obtained from the above Office (Co-Ordination Branch) on payment of a fee of 10s. (not refundable) for each Tender.

Please quote the above reference number. E5812

INDIA STORE DEPARTMENT

TENDER REF. NO. 16069/60/BMB/HAL

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of :

TENDER REF. No. 16069/60/BMB/HAL
UNIVERSAL CYLINDRICAL GRINDING MACHINE for plug cut, traverse, and internal grinding, maximum length 40in., maximum diameter 14in., swivel of works head and Table.

The Tender forms with Schedule and Specifications which are returnable on 29th September, 1960, may be obtained from the above Office (Co-Ordination Branch) on payment of a fee of 10s. (not refundable) for each Tender.

Please quote the above reference number. E5813

EDUCATIONAL

A.M.I.MECH.E., B.SC., City and Guilds, &c. Guarantee Postal Courses for all Exams. and Technical Divisions from Elementary to Degree standard including Automation Techniques. Approximately 95 per cent. successes. 148-page prospectus, free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London W.8. E114 A

UNVERSITY OF LONDON KING'S COLLEGE

TUTORIAL STUDENTSHIP IN CHEMICAL ENGINEERING

The College offers a TUTORIAL STUDENTSHIP in the Department of Chemical Engineering. The value is £425 a year, with free tuition in King's College, from 1st October, 1960. Applicants should have a good degree in Chemical Engineering, or a Post-graduate Diploma, and will be expected to undertake research for a higher degree and to give assistance with classes, limited to six hours a week. Maximum tenure four years.

Particulars and forms from the Registrar, King's College, Strand, W.C.2, whom completed applications should reach not later than September 16th. E5786 B

EDUCATIONAL

NORTHAMPTON COLLEGE OF ADVANCED TECHNOLOGY,
ST. JOHN STREET,
LONDON, E.C.1.

DIRECTION AND SUPERVISION OF SCIENTIFIC AND ENGINEERING PERSONNEL :

A PRACTICAL COURSE IN HUMAN RELATIONS FOR SENIOR MANAGERS

Fee 50 Guineas

This course is meant for Senior Managers, especially those concerned with research or development, and it is based on a new approach to training.

The course consists of sixteen full days' meetings, held at fortnightly intervals, from 12th October, 1960 to 7th June, 1961, inclusive. In view of the limited membership, nominations should be sent in as soon as possible. Further particulars from the Secretary, Northampton College of Advanced Technology, St. John Street, London, E.C.1.

E5784 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES NOT ORIGINALS OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED.

AN INTERESTING AND WELL-PAID JOB with great possibilities for further development is waiting for a man who can write lucidly about production and mechanical engineering. Although this appointment is based on a research centre, in exceptionally pleasant surroundings in the Midlands, opportunities arise for travel to all parts of Britain and, for the right man, possibly overseas as well. Excellent superannuation scheme.—Send details of career and present salary to BOX No. E5799, "The Engineer." A

ASSISTANT ELECTRICAL ENGINEER required for the Electrical Department of a large Manchester firm engaged in the manufacture of lifting and handling equipment up to 200 tons capacity. The applicant should be about 30 years of age, H.N.C., or Grad.I.E.E., with some experience in modern industrial control gear and circuitry. Duties will include specifying and ordering new equipment, and its application to products, together with factory electrical equipment. The post is permanent and pensionable with good prospects.—BOX No. E5795, "The Engineer." A

ASSISTANT WORKS ENGINEER wanted for large modern synthetic resin factory near Newport, Monmouthshire. Applicants should be aged 23-30 and must have served an apprenticeship and had drawing office experience ; minimum standard of education H.N.C. Salary £900 to £1250, according to experience and qualifications. The position offers good prospects of promotion. Contributory life assurance and pension scheme.—Write details of education and experience to BOX No. E5773, "The Engineer." A

BRITISH CONSTRUCTIONAL STEELWORK ASSOCIATION

Applications are invited for an appointment to the permanent staff offering considerable scope to the right person.

The ideal candidate would be a man keenly interested in the use of steelwork for buildings and bridges with some experience of related publicity work. He should be thoroughly familiar with the work of the constructional steelwork industry, hold a recognised engineering qualification and have a flair for public relations work. He should be able to prepare informative propaganda literature, to organise small study tours and have the ability to lecture to adult audiences.

There is a non-contributory pension scheme to which admission is granted after a qualifying period and the salary will be negotiated.

Applications, which will be treated with confidence, should be addressed to The Technical Adviser, British Constructional Steelwork Association, Artillery House, Artillery Row, London, S.W.1.

E5821 A

BRITISH LIGHT STEEL PRESSINGS LIMITED, Acton, W.3, require a BUILDING DRAUGHTSMAN with knowledge of structural steel work and local By-law procedure. Some knowledge of reinforced concrete desirable.—Write, stating age, experience and salary required. E2988 A

CHIEF DRAUGHTSMAN

Applications are invited for this Senior Appointment with a well-known Glasgow constructional and engineering company from qualified Engineers who have had previous experience in modern design and practices in constructional platework and ancillary work.

The successful applicant will be between 30 and 40 years of age and have drive and initiative. He will be responsible for the efficient running of the drawing office.

Contributory Pension Scheme.

Applications, giving full details of experience, qualifications and salary, together with copy testimonials, to BOX No. E2987, "The Engineer." A

SITUATIONS VACANT

DESIGN DRAUGHTSMAN, having initiative and sound general engineering experience, is required for a senior position in a small drawing office in our Rubber and Plastics Works in the North of England. Much of the work will be associated with the technical development and expansion of the factory, and will give scope for ingenuity and original design. Experience in the rubber industry, particularly hose and belting, would be an advantage, but good practical experience of machinery and plant layout is of more importance.

Applicants having H.N.C. will be preferred but less qualified men who have sufficient practical experience are invited to apply for this interesting and progressive vacancy. An attractive salary will be paid to the successful candidate and some assistance with housing will be available. The Company operates a group pension scheme.

Initial interviews for selected candidates can be arranged locally and enterprising applicants are requested to send full details of their career to date to BOX No. E5834, "The Engineer." A

DRAUGHTSMAN DESIGNER required for Equipment Department (responsible for new layouts, &c., in various parts of Fort Dunlop factory.) The work covers mechanical handling and/or design of automatic and semi-automatic machinery for rubber processing and tyre manufacture. (Rubber experience not essential but applicants should know something about mechanical handling and/or special-purpose machine design in other industries.) Holiday arrangements respected. Pension scheme ; five-day week ; excellent working conditions. Age range : 25-43.—Please write, giving brief details and commencing salary required, to Staff Officer (Reference E), Employment Department, Fort Dunlop, Erdington, Birmingham, 24. E5641 A

ELECTRICAL DRAUGHTSMAN

INDE COOPE LIMITED require an Electrical Draughtsman for the preparation of diagrams, estimates and specifications for a wide range of installations. O.N.C. (E) level qualification required. Salary range £750 per annum to £1000 per annum. Excellent working conditions, with a Staff Restaurant.

The Company operates a Pension Scheme, with substantial widows' benefits in the event of death before or after retirement.

Applications, in writing, please, to the Group Personnel Manager, Ind Coope Limited, Burton-on-Trent, giving full particulars of age, qualifications, &c.

E5794 A

ENGINEER

Splendid opportunity for printing technician, preferably single, with East African branch of London-based paper company. Knowledge of composing machinery desirable. Age 25-35 years. Salary: £1250 p.a. Free accommodation and initial and leave passages.—Details to Personnel Adviser, Spicers, Ltd., 19, New Bridge Street, London, E.C.4.

E5822 A

ENGINEERING DRAUGHTSMAN

required by the National Coal Board in London (Victoria area).

VACANCY No. X.1846/3. Experience of Plant Layout work in connection with Power Stations is desirable.

VACANCY No. X.1813/3. A knowledge of mechanisms and mechanical handling equipment and experience of mining machinery would be an advantage.

Applicants should have O.N.C. or equivalent qualification. Five-day week. Three weeks holiday (present arrangements honoured). Staff Restaurant, &c. Appointment superannuable, salary according to qualifications and experience, within £810 to £925.—Write for application form to Staff Department (quoting relevant No.), N.C.B., Hobart House, London, S.W.1, before 12th September, 1960.

E5800 A

ENGINEERS, DRAUGHTSMEN and all Technical staff, are invited to forward details of qualifications, etc., to Abbatt Technical Division, who will handle and negotiate on their behalf, without charge, any change of employment contemplated. Leading Organisations consult Abbatt, 25, Kensington High Street, W.8. WES. 0768-9. E2993 A

SITUATIONS VACANT

EXPERIENCED MANAGER

for a well known Machine Tool Merchants Business in London. Must have wide experience in the purchasing and selling of Second-Hand Machine Tools. Good prospects for suitable applicant.—Write, in confidence, full details BOX No. E5820, "The Engineer." A

LIFT ENGINEERS required for the erection and servicing of lifts in Nigeria and Ghana. Wide experience of this work is essential and some knowledge of the more complicated high-speed installation would be an added advantage. Appointments are to be made to the permanent staff, and there are also contract vacancies for periods of 24 months, salary dependent upon experience and terms of engagement, but in the region of £1300 to £1500 per annum with free furnished quarters and generous allowances.—Full particulars of experience to BOX No. E5828, "The Engineer." A

MAINTENANCE ENGINEER required by Multiple Hotel Company as ASSISTANT SUPERINTENDENT ENGINEER. Experience should cover Oil Fired and Solid Fuel Boilers, Lift installations and General Building maintenance. Some travelling, but domiciled in London area. Preference given to man of sea going experience wishing to settle ashore. Pension Scheme. Age up to 40.—Write, giving fullest details to BOX No. E5801, "The Engineer." A

MECHANICAL, ELECTRICAL AND CIVIL ENGINEERS required by North Eastern engineering office dealing with industrial power plants and electrification schemes. The applicants, who should be aged between 28 and 35 years, should be keen and able to work with minimum supervision. Minimum qualification is H.N.C., together with good experience in Thermal Plant/Electrical design layout and the ability to handle Contract work. Contributory Superannuation Scheme.—Reply, giving full details of age, experience and present salary to BOX No. E5674, "The Engineer." A

MECHANICAL ENGINEER. Graduate, aged 25-35, required as Assistant Works Engineer in Pharmaceutical Factory at Crawley. Duties include : Preventative Maintenance schedules, direct supervision of maintenance and constructional labour, construction schedules for plant installation, deputising for Works Engineer in all aspects of his duties (except building construction). This post offers scope for future development in an expanding business. Men with at least 5 years' experience in Mechanical Engineering in this field should write for application form to Personnel Manager, The Vitamins Group, Upper Mall, London, W.6. E5831 A

MECHANICAL ENGINEER required for company operating Singapore/Malaya. Preference given to Graduate Inst.Mech.Eng. Age 25-30, single. Commencing salary and allowances equivalent £1400 per annum. Free accommodation and Provident Fund.—Application which will be treated as confidential to : Box E.610, c/o Streets, 110, Old Broad St., E.C.2. E5836 A

PLANT AND MACHINERY VALUERS

required by well known City Firm. Wide experience in most classes of Machinery essential. Bonus and Pension Scheme in operation. Excellent prospects to suitable applicants.—Write BOX No. E5819, "The Engineer." A

PORT OF MANCHESTER ENGINEERING APPOINTMENT

Applications are invited for a Senior position on the staff of the Chief Engineer.

The position is one which offers excellent prospects of promotion and will carry a salary commensurate with the responsibilities entailed.

Candidates, who must be Corporate members of the Institution of Civil Engineers, should not only have extensive experience in dock and harbour construction and maintenance but should also have first class executive and administrative experience.

The successful candidate will be required to pass a medical examination and to become a member of the Company's Contributory Superannuation Scheme.

Applications, stating age, qualifications and full details of experience, should be addressed to the Chief Engineer (marked "Personal"), The Manchester Ship Canal Company, Ship Canal House, King Street, Manchester, 2, not later than the 30th September, 1960.

E5732 A

PROJECT ENGINEER, age 28-35, for work on new projects associated with factory expansion in Midlands. Experience in Mechanical engineering and Building & Services installation. Minimum qualification Higher National Certificate. Applications, giving details of age, education, qualifications, experience and when available.—BOX No. 2992, "The Engineer." A

RICKARD THOMAS & BALDWINS (SALES) LTD.

invite applications for

SALES REPRESENTATIVE

for Silicon Sheet.

A technical qualification such as H.N.C. or a degree in electrical or mechanical engineering is desirable. Previous selling experience is not required.

The Company operates a generous pension scheme, and prospects for advancement are good.

Applicants, who should be between the ages of 24 and 30, should write, giving full particulars, to :

Management Development Department,
Richard Thomas & Baldwins Limited,
47, Park Street, London, W.1.

E5793 A

SITUATIONS VACANT

STRUCTURAL STEELWORK DESIGNER required conversant with modern welded construction and B.S.S.449. Salary commensurate with experience and qualifications. First class prospects for the right man.—Apply to : G. R. Turner Limited, Langley Mill, Nottingham. E2977 A

TECHNICAL ASSISTANT REQUIRED by established Rotary Compressor Manufacturers. D.O. experience essential. Good salary to engineer with right technical background.—Apply Tech. Manager, the B.A. Holland Engineering Co. Ltd., Lindo Lodge, Chesham, Bucks. E2990 A

TECHNICAL REPRESENTATIVE required in connection with hire of large mobile cranes and associated services. Based on Rotherham to work N. Midlands area. Modern car provided. Heavy mechanical engineering experience essential. Some drawing office work and a successful sales record in similar field desirable.—BOX No. E5802, "The Engineer." A

WORKS MANAGER

Light Engineering Company in Rugby Area requires an experienced Works Manager. Candidates should have sound Mechanical and Production Engineering knowledge and have controlled a factory of 80-100 people, male and female. True appreciation of cost and commercial aspects are essential. Preferred age 35-45 years, with starting salary upwards of £1500 according to experience, &c. Good prospects and Pension Scheme.—Write in confidence, stating age, experience and qualifications to BOX No. 5829, "The Engineer." A

SITUATIONS VACANT

G. A. Harvey & Co. (London) Ltd.,

have a vacancy in the Heavy Fabrication Department for a

CHIEF DESIGN ENGINEER

of good general and technical education, and with mature experience in the design for construction of medium and heavy pressure vessels and heavy welded fabrications.

A sound knowledge is necessary of materials of construction, codes of practice and good modern manufacturing procedure.

Position carries a good salary with contributory superannuation, and assistance as necessary with housing.

Applications in confidence to :

The Manager of Engineering Projects,
G. A. HARVEY & CO. (LONDON) LTD.,
WOOLWICH ROAD,
LONDON, S.E.7.

E5787 A

SITUATIONS VACANT

GENERAL MANAGER

required for modern Engineering Works in East Anglia, about 250 employees.

Products are chiefly engineering components produced on mechanical and hydraulic presses, and also the manufacture of special precision machine tools.

Age 35 to 45 years. State experience and salary required to BOX No. E2991, "The Engineer."

A

SITUATIONS VACANT

COURTAULDS
Chemical Engineering Section
Require

DESIGNERS

at
Research Headquarters
Coventry.

For interesting and varied work concerned particularly with the design of experimental chemical pilot plants.

Applicants should hold an H.N.C. in mechanical engineering. Experience of pressure vessels, plant layout and fabricated structures would be an advantage.

Good salary. Co-partnership. Excellent sport and recreational facilities.

Write in confidence to the Labour Officer, Courtaulds Limited, Foleshill Road, Coventry.

E 5805 A

REAVELL-FAHIE LIMITED

Reavell-Fahie Limited requires the services of two

GRADUATE ENGINEERS OR PHYSICISTS

for staff duties at Ranelagh Works, Ipswich

The company, a subsidiary of Reavell & Co., Ltd. was formed to take over, develop and expand the parent company's interests in the field of automatic control and instrumentation in heavy industry. Since 1927, the parent company has exploited the well known Reavell Askania hydraulic controller, which is capable of further development to be undertaken by Reavell-Fahie in this country in collaboration with its associates in the U.S.A.

One of the chosen applicants will be appointed as personal assistant to the Managing Director, with special reference to technical sales. The other will be appointed as personal assistant to the Director responsible for Production and Development.

Both are positions of trust and responsibility and appropriate salaries will be paid.

Applications will be treated in confidence and should be addressed to the Managing Director Reavell-Fahie Ltd., Ranelagh Works, Ipswich, Suffolk.

E5728 A

CHARTERED PATENT AGENT
(ENGINEERING)

A leading industrial company engaged in a wide field of manufacture of which engineering forms a substantial part, both in the United Kingdom and overseas, requires a senior qualified Patent Agent having a degree in Engineering. The post is based at the Company's operating headquarters in the Midlands and the work is varied and interesting. Initial salary not less than £2000 per annum, pension scheme and excellent terms of service. Preferred age under 35. *Reference Number* 95.

Please reply in confidence quoting Reference Number to :—

Robert Clive (Consultants) Limited

27, ALBEMARLE STREET, LONDON, W.1.

E5783 A

ENGLISH ELECTRIC AVIATION LTD.,

Guided Weapons Division

Stevenage, Herts.

JUNIOR ENGINEERS

Our Mechanical Engineering Department which carries out a wide range of Mechanical Engineering Design and Development has a number of vacancies for :

JUNIOR DEVELOPMENT ENGINEERS (ELECTRICAL)

are required for the Development and Testing of ground equipment. The work is very varied and covers a wide range of electrical development as applied to complex special purpose machinery.

Applicants should have :

(1) G.I.E.E., H.N.C. or equivalent.
(2) been trained in electrical power engineering followed by some years' practical experience.
(3) a knowledge of electrical machines.

Some Drawing Office experience would be an advantage in these positions.

JUNIOR DESIGN ENGINEERS (MECHANICAL AND ELECTRICAL)

are required for the design of a very wide range of ground equipment used in launching systems. This work covers dynamic, structural, hydraulics and packaging problems and offers an *excellent opportunity for Design Draughtsmen* of good calibre to obtain Design Engineer Experience.

Applicants should be :

(1) Not less than 27 years of age.
(2) of H.N.C., G.I.Mech.E., G.I.E.E. standard.
(3) trained in workshop practice in the mechanical engineering field.
(4) experienced in design drafting for some years.

Applications should be sent to : Technical Personnel Officer, c/o Dept. G.P.S., English Electric House, Strand, W.C.2, quoting reference ER1316A

A member of the BRITISH AIRCRAFT CORPORATION

E5817 A

Classified Advts. continued on page 130

SITUATIONS VACANT

WELDING ENGINEER

wanted by Cochran and Co., Annan, Ltd., to meet expanding commitments.

He will be responsible to the Works Manager for all welding in the factory, training and testing of Class I welders and development of new techniques.

Applicants must have up-to-date knowledge and experience of all modern automatic and hand-welding techniques for Carbon, Stainless and other alloy steels.

Housing can be provided and help given in removal expenses ; superannuation scheme.

The man appointed will have the opportunity to develop in a progressive and growing organisation.

Applications with particulars of experience to be addressed to :

The Secretary,
COCHRAN & CO., ANNAN, LTD.,
NEWBIE WORKS, ANNAN

E5791 A

SITUATIONS VACANT

PRODUCTION CONTROLLER

Established medium engineering Company of 1000 employees, pleasantly situated in the South of England, wishes to appoint a Production Controller.

The man we are seeking will have had a wide experience in a similar capacity on small batch production. He will have unlimited drive and enthusiasm and will be thirty to forty years of age.

Salary range £1200 to £1400, according to present station.

Send full details of training, qualifications and experience in strictest confidence to BOX No. E2986, " The Engineer."

A

SITUATIONS VACANT

DRAUGHTSMEN

Draughtsmen are required at the Midlands Research Station, Solihull.

The duties are interesting and will include work on the design of pilot and prototype plant associated with the development of new high-pressure processes for the production of town gas.

Candidates should possess at least an O.N.C. certificate in Mechanical Engineering.

The salary for the appointments, which are pensionable and subject to medical examination will be within the range of £770-£1015 per annum.

Applications, stating age, education and experience, should be addressed to the Industrial Relations Officer,

WEST MIDLANDS GAS BOARD,
6, Augustus Road, Edgbaston, Birmingham, 15

E190 A

SITUATIONS VACANT

DESIGN DRAUGHTSMEN

fully experienced in heavy mechanical conveyor design including associated structures, required by Huntington, Heberlein & Co., Ltd. Good salary, 3 weeks' holiday, 5-day week, luncheon vouchers and pension scheme.—Write, giving full details, age, previous experience, etc., to Staff Dept., 28-29, Dover Street, London, W.1.

E5782 A

MECHANICAL ENGINEER

Countrywide commercial engineering organisation with headquarters in the North of England seeks to augment its Headquarters engineering staff by the addition of a mechanical engineer with an interest in

NUCLEAR ENGINEERING AND ELECTRONICS.

Further training will be arranged if necessary. Position is pensionable. Salary by arrangement.

Applicants who should be aged about 30 should have reached degree standard and should give full details of their careers and qualifications in their letter of application.

(Write BOX No. E 5815.) "The Engineer"

A

PERSONNEL ADMINISTRATION LIMITED

MANAGEMENT CONSULTANTS

Our Appointments Division has been asked to advise on the following post :—

TECHNICAL MANAGER — **S. England**

for a company which is part of a prosperous international organisation, offering an engineering service to industry and which is shortly moving into a new factory outside London. A new department will be formed by the man appointed to cover research, development and design in the mechanical engineering and metallurgical fields applicable to the company's products. Responsible to the Managing Director, the Technical Manager will be given every support in formulating long-term and short-term policies with a view to introducing improved products and processes and opening up new markets. Ability in applied research, coupled with a practical approach to administration, production and marketing, will be sought in candidates, aged 30-45, who must possess a good Honours degree in mechanical engineering or physics. Experience at a responsible level in research, design and a familiarity with mass production are desirable qualifications. Some overseas travel is envisaged. Starting salary in the range £3–4,000, plus car, Top Hat pension and four weeks' holiday. (Ref. 5468/TE)

The identity of candidates will not be revealed to our clients without their prior permission. For the convenience of clients and candidates we have Regional Offices in Glasgow, Manchester, Bristol and Birmingham but, in the first instance, applicants should forward brief details, quoting the reference number, to :—

PERSONNEL ADMINISTRATION LIMITED
APPOINTMENTS DIVISION, 2, ALBERT GATE, LONDON, S.W.1.

E5776 A

THE NUCLEAR POWER GROUP

requires

RESEARCH ENGINEERS

With the contract for Dungeness Nuclear Power Station, The Nuclear Power Group is now actively engaged upon the construction of four major nuclear power stations as well as designs for new plants in the United Kingdom and Overseas.

Applications are invited for the following positions :

SENIOR RESEARCH ENGINEER—to be responsible for a section of the Group's Research programme on plant and instrumentation problems encountered in the design of nuclear power stations. The work will be mainly, but not exclusively, of a mechanical nature, and will demand a sound knowledge of modern experimental techniques.
The post calls for an Honours Graduate, between 28 and 35 years of age, and with wide and varied development experience.

SENIOR RESEARCH ENGINEER—to undertake the mechanical development of fuel elements. The work will demand practical experience in the fields of vibration, structure stability and the use of materials within the creep range.
Candidates must be Honours Graduates between 25 and 32 years of age with a thorough appreciation of good mechanical design. Previous experience of fuel element development will be desirable but not essential.

TWO JUNIOR RESEARCH ENGINEERS—to work on problems associated with :—
(a) Plant and Instrumentation.
(b) Mechanical aspects of fuel elements.
(c) Reactor Heat Transfer and pressure circuit fluid flow.

Candidates must be graduates who have served a recognised apprenticeship and will be expected to show initiative, drive and the desire to advance in the field of work chosen. Previous experience is not essential.

The positions will be tenable at the Group's Knutsford research laboratory and will require visits to other laboratories within the Group at Manchester, Newcastle-on-Tyne and elsewhere.

Assistance with housing will be offered to married men.
Applications, giving details of age, qualifications and experience, should be addressed to :

THE PERSONNEL MANAGER,
THE NUCLEAR POWER GROUP,
RADBROKE HALL,
KNUTSFORD,
CHESHIRE.

Quoting reference :—TE/RES/7.

E5781 A

APC

ENGINEERING RESEARCH & DEVELOPMENT

GROUP LEADER

(HEAT TRANSFER)

An experienced qualified ENGINEER is required to take charge of the experimental HEAT TRANSFER work on fuel elements which is undertaken at the Company's Laboratories at Heston, Middlesex. He will be responsible for planning and supervising the work and for initiating research programmes on future projects. A sound theoretical background in heat transfer is essential, together with several years' active development experience.

EXPERIMENTAL ENGINEERS

required of H.N.C. standard to join experimental teams dealing with Heat Transfer, Fluid Mechanics and Experimental Stress Analysis.

Vacancies also exist in these teams for RESEARCH ASSISTANTS of O.N.C. or G.C.E. " A " level standard.

Full details of qualifications and career should be sent to :

The Personnel Manager (Ref. E/138),
Atomic Power Constructions Limited,
P.O. Box 90,
28 Theobalds Road, W.C.1.

E5789 A

SITUATIONS VACANT

NORTHERN ALUMINIUM CO. LTD.
BANBURY (Oxon)
(a member of the Aluminium Ltd. of Canada group of companies)
require

SENIOR DESIGN DRAUGHTSMAN

to undertake and supervise work in all fields of application of aluminium including building, road and rail transport, shipbuilding and general engineering.

Sound knowledge of structural design required and experience of aluminium preferred.

Write giving details of age, education and career to date to PERSONNEL OFFICER, NORTHERN ALUMINIUM COMPANY LIMITED, BUSH HOUSE. ALDWYCH, LONDON, W.C.2.

E5817 A

SITUATIONS VACANT

POWER PLANT DIVISION

A well known firm of Machinery Engineers has a vacancy for a

SALES ENGINEER

Preference will be given to those having experience in industrial applications of Internal Combustion Engines, Air Compressors, Pressure Vessels and Pumps and who are between 25/35. Commencing salary £850/950 and there are excellent prospects.

Write giving details of age and experience to **Box No. E5797, "The Engineer."**

A

SITUATIONS VACANT

FOSTER WHEELER LIMITED

SENIOR DESIGN ENGINEER

required for interesting work in a wide field of heat-transfer application with particular emphasis on large and small water-tube boilers. The work is interesting and varied. Applicants must have the ability and initiative to design complete units and ancillary equipment.

PROPOSAL DRAUGHTSMEN

related work on complete Land Water-Tube Boiler installations. Applicants should have some previous experience of Water-Tube Boiler construction and layout.

Salaries will be dependent on age, qualifications and experience, which please state.

Staff Manager (L)
Foster Wheeler House, 3 Ixworth Place, London, S.W.3.

E5808 A

SITUATIONS VACANT

APPLEBY-FRODINGHAM STEEL COMPANY, SCUNTHORPE, LINCOLNSHIRE,

invite applications for a

SENIOR DESIGNER

with experience of heavy PLATE AND SECTION ROLLING MILLS PLANT.

Permanent situation with interesting and varied work.

Apply, giving age, full particulars of experience, &c., to The Chief Engineer.

E5804 A

Monsanto

MECHANICAL DESIGN ENGINEERS

required to assist Mechanical Design Engineers on Project Engineering. The major responsibilities are the preparation of specifications and requisitions and the co-ordination of draughtsmen's work. It will be necessary to spend periods on site during construction and testing.

The posts will be suitable for men aged 28 years or more, with B.Sc. in mechanical engineering or H.N.C. with endorsements for A.M.I.Mech.E. Some previous experience in a similar position is desirable—2 to 4 years in the case of graduate qualifications ; 4 to 6 years for H.N.C. qualifications.

These posts are based on the Engineering Department in London and offer excellent starting salaries and career prospects ; non-contributory pension scheme and other benefits. Applications, giving details of age, qualifications and experience, should be sent to :

THE STAFF RELATIONS OFFICER (DL166)
MONSANTO CHEMICALS LIMITED,
MONSANTO HOUSE,
10/18 VICTORIA STREET,
LONDON, S.W.1.

E5788 A

[redacted]

RESEARCH AND DEVELOPMENT MECHANICAL ENGINEERS

If you have a good honours degree in Mechanical Engineering and would like to hold a responsible job in an expanding industry, you are invited to write about yourself to Mr. A. de Dani, Manager, Research and Development, Fibreglass Ltd., St. Helens, Lancashire.

You would be given varied and interesting work on all process and product development on existing plant and design and operation of new plant and processes. Based on St. Helens, you would have occasion to visit works in Glasgow and Birkenhead.

E5777 A

MACHINE TOOLS — B·S·A tools — AUTOMATION

First class DESIGNERS and DEVELOPMENT ENGINEERS are required for work on an intensive Development Programme, involving redesign of present lines and introduction of new models.

Development Projects will cover many phases of Automation, including Special Machines and Link Lines.

Men with sound basic training, good design **experience and qualifications up to H.N.C. minimum** are invited to apply.

Salaries commensurate with qualifications and experience.

The general terms of employment, which includes a Pension Scheme, are excellent.

Brief particulars should be sent, in confidence, to :

THE TECHNICAL DIRECTOR,
B.S.A. TOOLS LTD.,
KITTS GREEN, BIRMINGHAM 33

E5778 A

STRUCTURAL STEELWORK

Design and Supervisory Staff

One of Britains largest steelworks now has vacancies in its Development Department for:

Design Engineers

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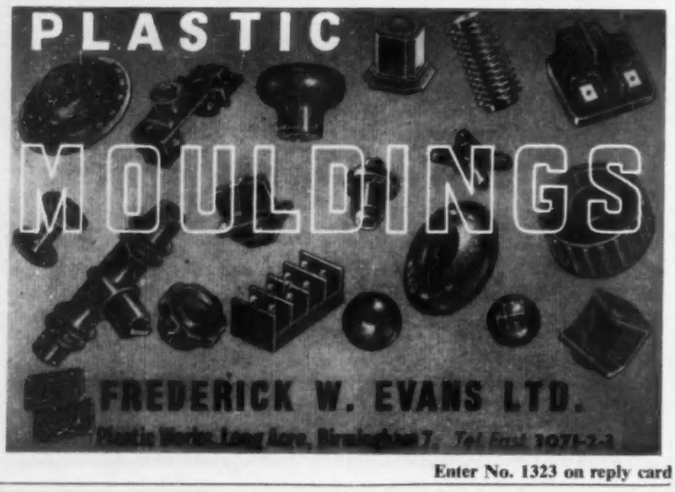

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October 19	Miscellaneous stores.	Northern Command Ordnance Sub-Depot, Barlow, Nr. Selby, Yorks.	BARTLE & SON, (Dept. L), 50-52 Merrion St., Leeds, 2 (Tel.: 20898).
October 25	Machine tools and miscellaneous stores.	M.O.A. Storage Depot, Byley, Nr. Middlewich, Cheshire. (Sale at Cheetham Town Hall, Manchester 8).	J. H. NORRIS & SON, (Dept. L), 9, Albert Square, Manchester 2. (Tel.: Blackfriars 8373).
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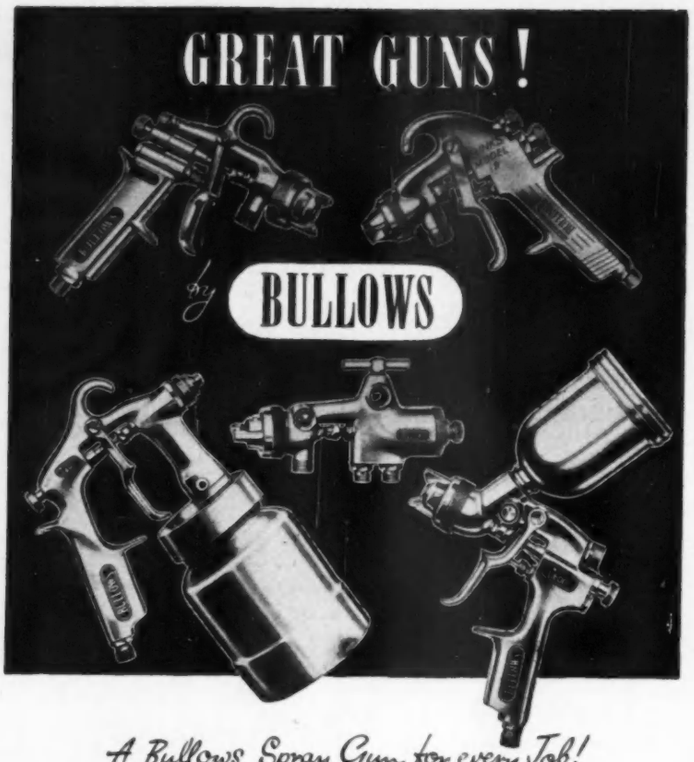

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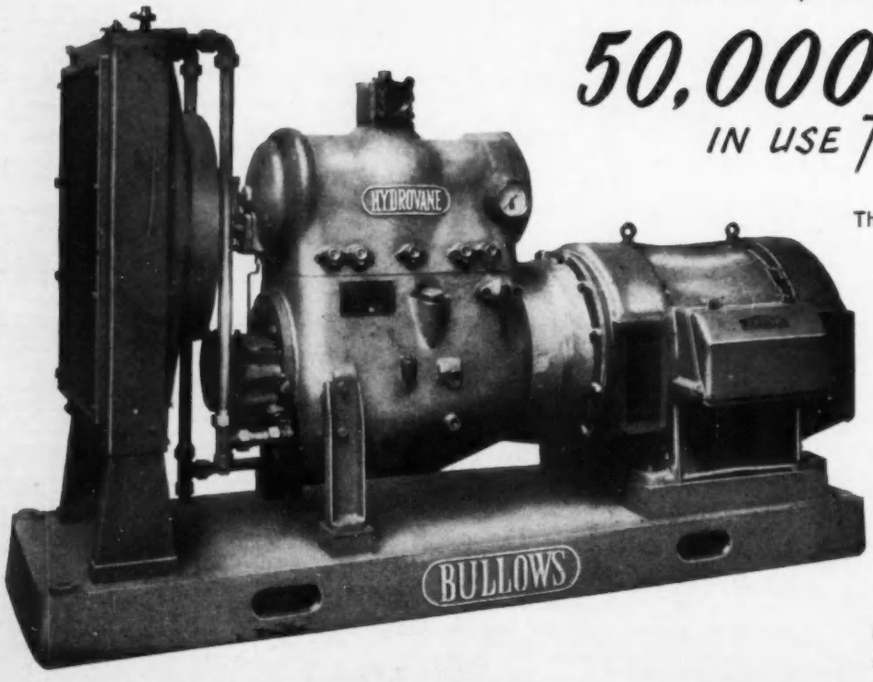

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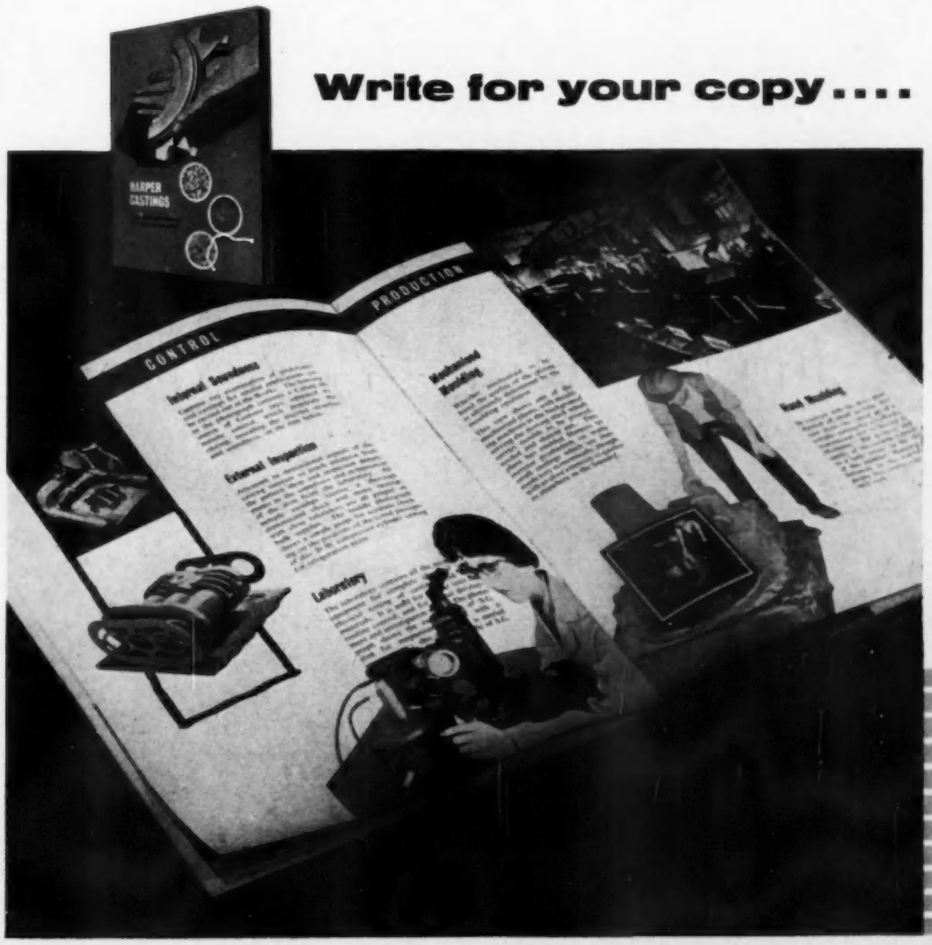

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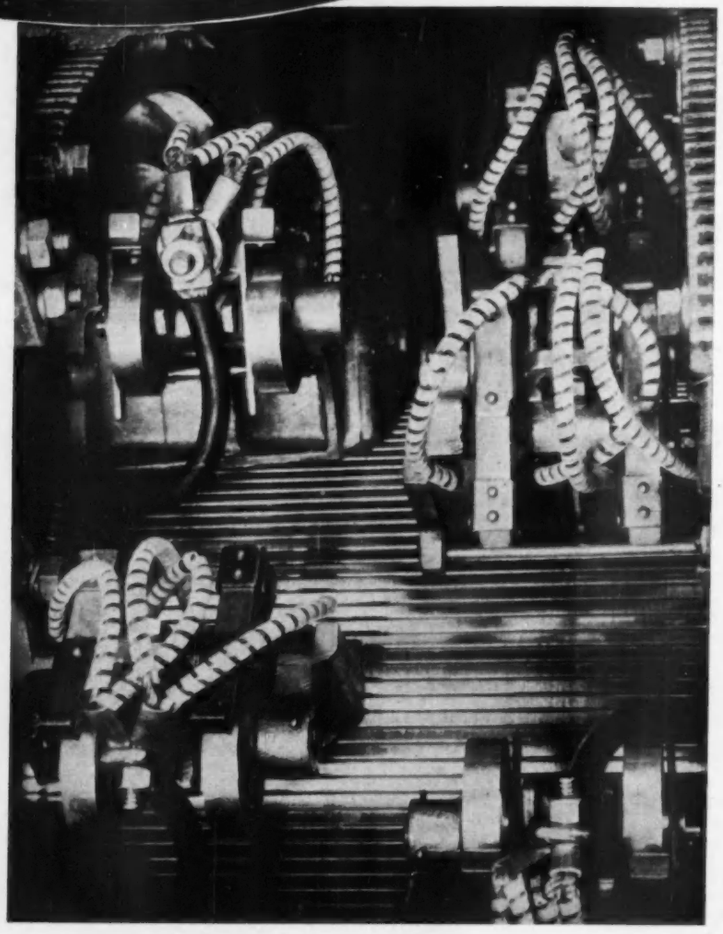

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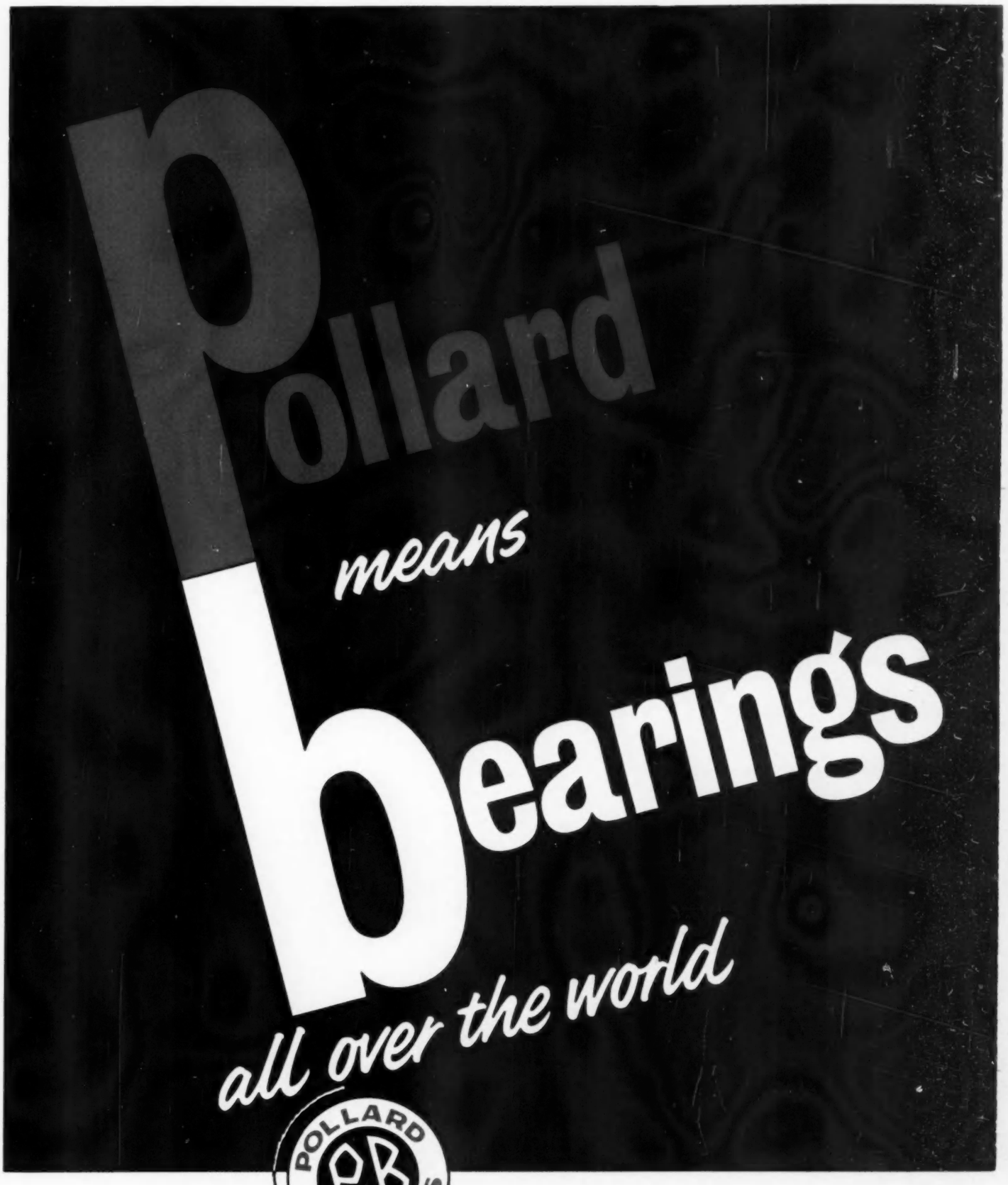

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